NASA SP–7037 (264)
April 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
SCIENTIFIC & TECHNICAL INFORMATION

NASA SP-7037 (264)
April 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Program
Washington, DC 1991

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 744 reports, journal articles, and other documents originally announced in March 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-13399 — N91-15122
IAA (A-10000 Series)	A91-16993 — A91-20488

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

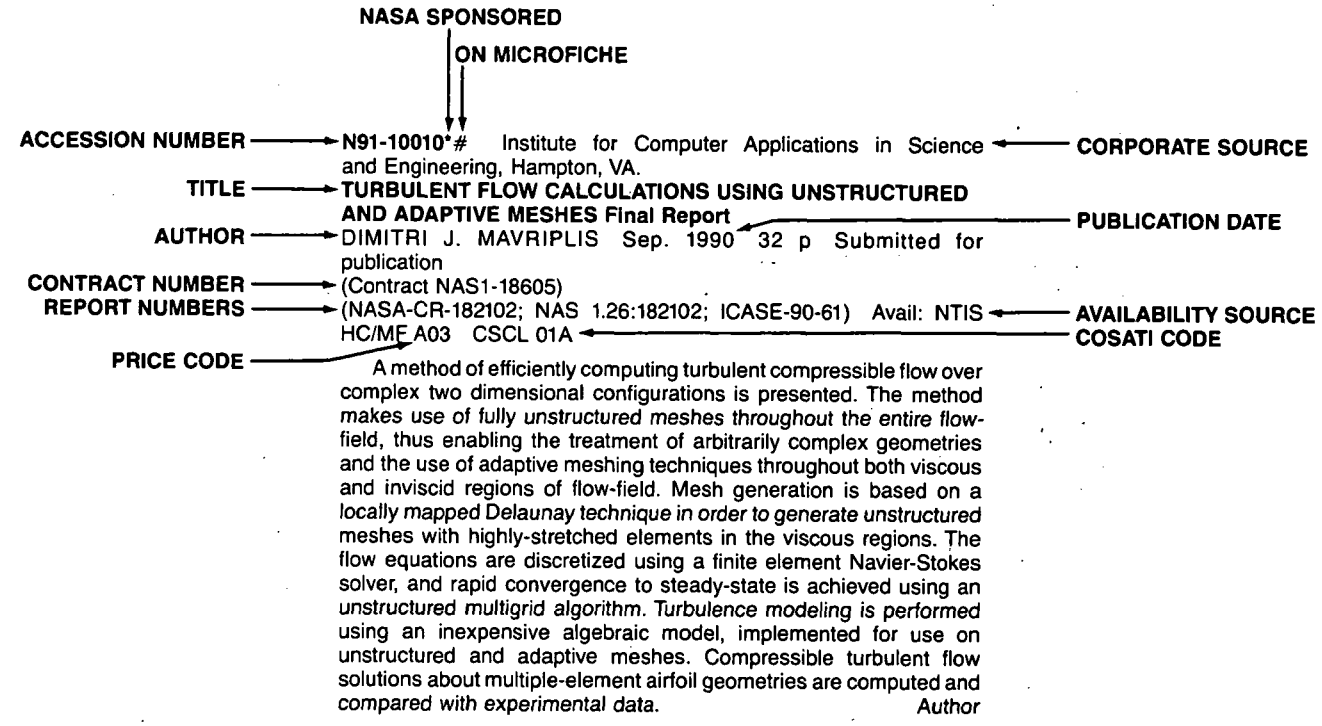
Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1991 will be published in early 1992.

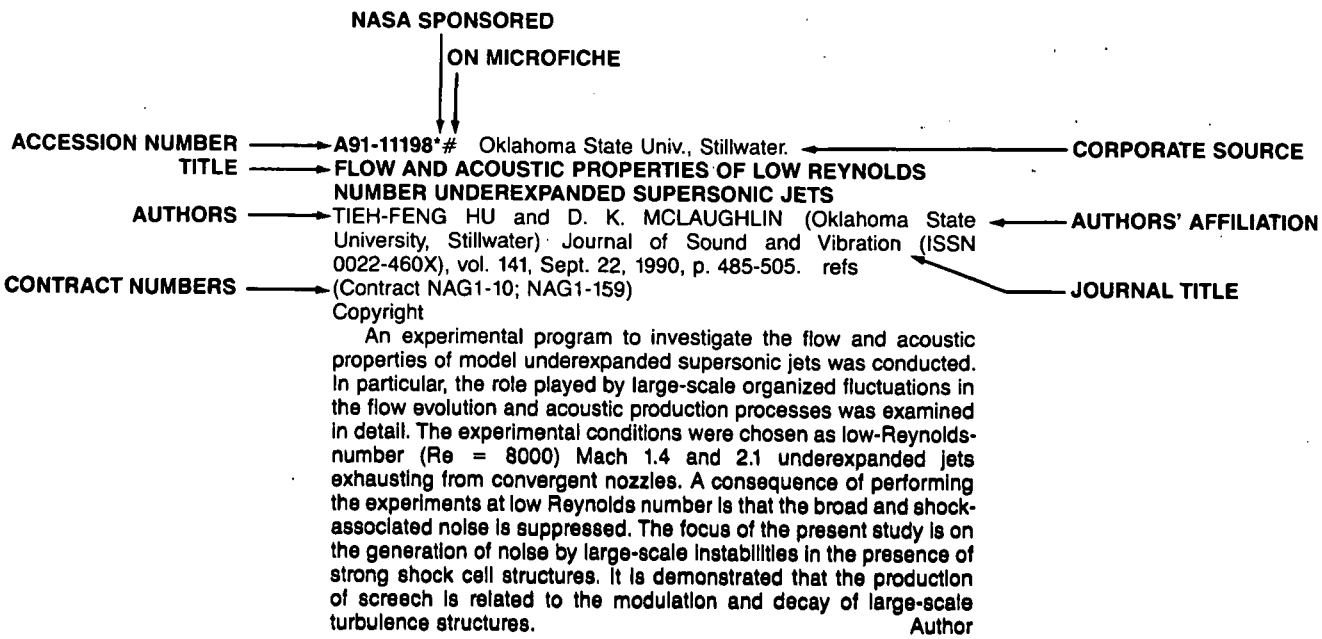
Information on availability of documents listed, addresses of organizations, and NTIS price schedules are located at the back of this issue.

CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 264)

APRIL 1991

01

AERONAUTICS (GENERAL)

A91-17201
AHS, ANNUAL FORUM, 46TH, WASHINGTON, DC, MAY 21-23, 1990, PROCEEDINGS. VOLUMES 1 & 2
Alexandria, VA, American Helicopter Society, 1990, p. Vol. 1, 751 p.; vol. 2, 632 p. For individual items see A91-17202 to A91-17308.
Copyright

The present conference on helicopter technologies discusses the application of chaos methods to higher harmonic control of rotors, a FEM model reduction application to rotorcraft structure applications, the numerical simulation of powered-lift flows, V/STOL concepts for special applications, advanced rotorcraft transmissions, advanced helicopter avionics, three-dimensional shock-fitting for transonic rotor acoustics, a model-based procedure for low vibration rotor design generation, and an integrated aerodynamic load/dynamic approach to optimum rotor blade design. Also discussed are numerical optimization for tiltrotor blade aerodynamic design, aging U.S. Army aircraft, mission/task analysis for weapon system cost and risk reduction, night vision goggle compatibility with color displays in Army aircraft, the structural evaluation of a composite fuselage structure, composite actuators for airborne systems, wake surveys of advanced rotor platforms, safe strength/damage-tolerance assessment, cargo rotorcraft in future Army operations, tests of the V-22 flight control system, heliport/vertiport development, advanced surface-hardening technologies, and main rotorblade bonding automation. O.C.

A91-17240
AGING ARMY AIRCRAFT
LEWIS NERI (U.S. Army, Aviation Systems Command, Corpus Christi, TX) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 571-580.
Copyright

Reliability-centered maintenance is a broadbased management and system engineering program that emphasizes a preventive approach to maintenance. Corrosion detection and prevention are principal concerns in this program which utilizes an analytical approach based on fault tree analysis to facilitate development of improved airframe condition evaluation/aircraft analytical corrosion evaluation and preshop analysis. The U.S. Army Depot Engineering and Reliability Centered Maintenance Support Office is also investigating ion implantation and plasma chemical vapor deposition techniques to determine their feasiblity for prevention of corrosion. R.E.P.

A91-17241
MAINTENANCE TRAINING IN SUPPORT OF THE ARMY'S AGING HELICOPTER FLEET
THOMAS M. WALKER (U.S. Army, Aviation Logistics School, Fort Eustis, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 581-589.
Copyright

The Army's aging helicopter fleet includes nearly 7000 aircraft. The average age of these aircraft approaches 19 years. Current plans will not transition these aging aircraft out of the force until well into the year 2007. After full implementation of the Army Aviation Modernization Plan, the fleet will consist of approximately 3500 modern aircraft. Military training programs must provide a viable support structure for these systems, while simultaneously meeting the requirements of the UH-60, AH-64, CH-47D, OH-58D and the LH. This paper will examine: unique training challenges and requirements; the potential for generic/apprentice maintenance training; training devices and the integration of high technology training techniques in support of aging fleet aircraft. Author

A91-17242
MATERIAL SUPPORT ISSUES FOR AGING ROTARY WING AIRCRAFT
STEPHAN L. RITCHEY (U.S. Navy, Product Support Directorate, Cherry Point, NC) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 591-595.
Copyright

This paper will deal with some of the main problems concerning material support of older models of rotary wing aircraft and some of the decisions which need to be made in order to keep the support adequate to maintain readiness goals which have been established. The paper will examine material support issues such as the management of consumables, management of repairables, proper implementation of engineering changes, and replacement of components which have reached their service lives. These issues will be examined from two different viewpoints: first, whether they are generic issues with specific issues, and second, whether the trend in managing these issues is becoming more positive or degenerating. The paper reflects the views of the senior logistics manager for 341 fielded H-46 aircraft and emphasizes the day-to-day realities of that task rather than the theoretical aspects involved in logistics planning tasks. Author

A91-17243
THE V-22 OSPREY LOGISTICS PROGRAM PREPARING FOR THE FUTURE
HARRY E. WHEELER (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 597-603.
Copyright

This paper addresses development of the supportability system in conjunction with the design of the V-22 'Osprey' multiservice aircraft. The V-22 development program has been unique in its early and continuous application of 'up front logistics' during development. Integrated teams of logistics, systems, and design engineers were put in place at the beginning of the preliminary design phase to ensure maximum integration of logistics. Design approaches were influenced to enhance supportability throughout the development process by participation in trade studies, mock-up reviews and preliminary and critical design reviews. This paper summarizes major logistics accomplishments to date, and

innovative techniques and lessons learned, which have contributed to development of a fully operational and supportable system. Author

A91-17244
ADDSS/EDRAS INFLUENCING PRELIMINARY DESIGN FOR ENHANCED SUPPORTABILITY
ROBERT M. BEGGS (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 605-611.

This paper presents an overview of an Automated Design Decision Support System (ADDSS). It has long been recognized that the most cost effective place to improve the Supportability/Operability (S/O) of a weapons platform is in the preliminary design phase when Reliability, Maintainability, Safety and Human Factors features can be easily integrated into the system configuration. ADDSS is a computer based preliminary design environment that encourages design for S/O along with traditional performance related goals. ADDSS operates in concert with the Electronic Document Retrieval and Annotation System (EDRAS) which provides easy access to existing databases and automates the computation of baseline statistics. Author

A91-17252* Sikorsky Aircraft, Stratford, CT.
STRUCTURAL EVALUATION OF COMPOSITE FUSELAGE STRUCTURE FABRICATED USING A THERM-X PROCESS
CHRISTOS KASSAPOGLOU, ALBERT J. DINICOLA, and JACK C. CHOU (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 671-682. refs
(Contract NAS1-18799)

An experimental and analytical program has been implemented to evaluate the structural performance of complex composite parts made using THERM-X processing techniques. Preliminary analysis shows 22-percent cost savings for parts made with a THERM-X process over parts made with conventional manufacturing methods. Results of building-block tests from the coupon to the element level, which represent structural details of the curved integrally stiffened panel selected as the full-scale article, are also reported. Comparisons with baseline results and analytical predictions show that THERM-X processing yields parts with stiffness and strength comparable to or slightly better than conventional manufacturing procedures. Compression strength after low-speed impact damage (caused by a drop weight impactor) is also comparable to parts fabricated with conventional methods. Author

A91-17264
FINDING THE NEEDLE IN THE HAYSTACK - RESULTS OF THE ARMY FLIGHT SAFETY PARTS SURVEILLANCE PROGRAM
ROBERT W. ARDEN and CYNTHIA A. ROSS (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 819-824.

Significant results of the U.S. Army's ongoing Flight Safety Parts (FSP) Surveillance Program have been compiled and are presented in this paper. Beginning with a brief history of the Army FSP Surveillance Program and a discussion of its basic elements, results of current surveillance testing are presented in a generalized format and the objectives of ongoing surveillance testing are outlined. Finally, insight gained from these test results is offered for consideration. Rather than detailing specific aircraft systems or part numbers, the intent of this paper is to show the reasoning behind the particular component selection or test condition and the lessons learned for application to future surveillance efforts. Results show valuable information has been gained through the surveillance program regarding qualification, manufacturing, maintenance, and in-service/environmental degradation of flight safety parts. Author

A91-17267
DAMAGE TOLERANCE ASSESSMENT OF THE HH-53 HELICOPTER
DOUGLAS E. TRITSCH, GEORGE J. SCHNEIDER (Sikorsky Aircraft, Stratford, CT), GARY CHAMBERLAIN (USAF, Air Logistics Center, Robins AFB, GA), and JOHN W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 841-849. refs

The success of the damage tolerance approach has provided the Air Force with an effective structural maintenance plan for its inventory of fixed wing aircraft and engines. As a follow-on, the Air Force (WR-ALC) contracted Sikorsky Aircraft to perform a damage tolerance assessment (DTA) of the HH-53 helicopter. The objective was to determine if DTA could be applied to selected helicopter rotor and airframe structure to provide safe and economic force management. The DTA methodology used in this study was based on previous experiences of the Air Force with fixed wing aircraft and engines. The efforts and results of this damage tolerance investigation will be discussed in detail. Conclusions, lessons learned, and recommendations will be discussed in reference to the damage tolerant capabilities of the selected HH-53 helicopter structure. Recommendations for the DTA requirements of new designs will also be discussed. Author

A91-17269
A COMPUTATIONAL METHOD FOR THE DETERMINATION OF STRUCTURAL RELIABILITY OF HELICOPTER DYNAMIC COMPONENTS
AUDBUR E. THOMPSON and DAVID O. ADAMS (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 859-873. refs

Results are presented from a preliminary evaluation of absolute structural reliability on three UH-60A helicopter main rotor components, as well as a comparison of retirement times based on '0.999999 reliability' with retirement times conventionally calculated by the manufacturer. The statistical retirement times are ascertained through a computer simulation of actual in-flight damage, using strength, loads, and usage data randomly selected from predetermined distributions. The results obtained indicate that the '0.999999 reliability' goal is already achievable with current methodology. O.C.

A91-17283
INTERNATIONAL ASPECTS OF CIVIL HELICOPTER OPERATORS
FRED A. MOORE (Canadian Helicopters, Ltd., Richmond, Canada) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1037-1040.

Many civil helicopter operators are, and long have been, quite international. This is exemplified by the industry's trade association, Helicopter Association International, with members in more than 40 countries. This paper addresses international commonalities, and then discusses events that will influence the industry's future. Author

A91-18552
NONDESTRUCTIVE TESTING OF AGING AIRCRAFT
D. J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1179-1183.

A supplemental inspection program has been developed for aging aircraft. During this sampling program, inspections are carried out on an item-by-item basis for each principal structural element (PSE). Each PSE always stands by itself; that is, inspection start points, inspection intervals, detectable flaw sizes, etc., are generally different for each PSE. Inspection results and fleet status are computerized so that data may be stored, retrieved, and processed for each PSE. When fatigue damage is found, a special supplemental inspection document service bulletin is issued with inspection, repair, and terminating modification instructions to ensure continued safety. Author

A91-18725
OUR AGING AIRLINERS. II
TOM RHODES Aerospace Engineering (ISSN 0736-2536), vol. 10, Dec. 1990, p. 25-28.
Copyright

The paper elaborates on the results of a public survey which blamed the increased age and poor maintenance of the aircraft for the lowered level of flight safety. The two factors are analyzed in their complex relation to several other issues such as human factors, financial restrictions, design and safety considerations, and prototype testing procedures. The results of the analysis show that, although the age of the aircraft has increased during the last several years, safety has improved since 1960, and that only three percent of all incidents which result in a 'hull loss' can be traced back to structural causes. It is concluded that the human factors have to be of primary concern since the majority of accidents are due to human errors, errors in inspection and maintenance, and errors in the original design. B.P.

A91-18899
BOEING'S 777 - BREAKING THE HABITS OF A LIFETIME
BILL SWEETMAN and WILLIAM H. GREGORY Interavia Aerospace Review (ISSN 0020-5168), vol. 45, Dec. 1990, p. 1064, 1065, 1067, 1068.
Copyright

An overview is presented of the design and development concepts that have been considered for the 777, an advanced twin-engine, long-range commercial transport, that fits into a size category between the 767 and 747. The design embodies a round fuselage and folding wings that represent new adaptations for this manufacturer. The 777 wing is optimized for range and take-off performance, having more span than the original 747 wing, but with a higher aspect ratio and 16 percent less area; it has a greater aspect ratio than the 767 wing, a lower thickness-to-chord ratio, and cruises faster at M 0.83. Advanced powerplants under study include the ducted propeller concept. The outboard of the wings will fold upward 8 m, thus reducing the span to approximately the same as todays DC-10. This wing-fold is to be a customer option. R.E.P.

N91-14273*# *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, CA.
TABULATION OF DATA FROM THE TIP AERODYNAMICS AND ACOUSTICS TEST
JEFFREY L. CROSS and WILSON TU (DeAnza Coll., Cupertino, CA.) Nov. 1990 410 p
(NASA-TM-102280; A-90069; NAS 1.15:102280) Avail: NTIS HC/MF A18 CSCL 01/2

In a continuing effort to understand helicopter rotor tip aerodynamics and acoustics, researchers at Ames Research Center conducted a flight test. The test was performed using the NASA White Cobra and a set of highly instrumented blades. Tabular and graphic summaries of two data subsets from the Tip Aerodynamics and Acoustics Test are given. The data presented are for airloads, blade structural loads, blade vibrations, with summary tables of the aircraft states for each test point. The tabular data consist of the first 15 harmonics only, whereas the plots contain the entire measured frequency content. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A91-17023
HYPERSONIC FLOW PAST DELTA WINGS WITH BLUNTED EDGES [GIPERZVUKOVOE OBTEKANIE TREUGOL'NYKH KRYL'EV S ZATUPLENNYMI KROMKAMI]
S. A. GOROKHOV, V. V. EREMIN, and A. M. POLIAKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1990, p. 175-179. In Russian. refs
Copyright

A method is proposed which makes it possible to calculate hypersonic flow of an ideal gas past delta wings with blunted edges over the aspect ratio range 100-200. Systematic calculation are carried out for delta wings for free-stream Mach 6-20, angles of attack 0-20 deg, and sweeps 60-80 deg, and the results are processed using hypersonic similarity parameters. The results confirm numerically the effect of flow spreading in the plane of symmetry of delta wings with blunted edges. V.L.

A91-17024
EFFECT OF THE SHAPE OF THE BLUNT LEADING EDGES OF A DELTA WING ON THE HEAT TRANSFER COEFFICIENT DISTRIBUTION OVER THE WING SURFACE [O VLIIANII FORMY ZATUPLENIIA PEREDNIKH KROMOK TREUGOL'NOGO KRYLA NA RASPREDELENIE KOEFFITSIENTA TEPLOOTDACHI PO EGO POVERKHNOSTI]
G. V. SMYGINA and A. IA. IUSHIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1990, p. 180-183. In Russian. refs
Copyright

The effect of the shape of the blunt leading edge of a delta wing on heat transfer was studied experimentally in a supersonic wind tunnel for Mach 5 and angles of attak of 10 and 15 deg. It is shown that the leading edge shape has a strong effect on heat transfer toward the edge and the upper surface of the wing. Details of the tests and experimental results are presented. V.L.

A91-17102
MODELING OF TURBULENT BOUNDARY LAYERS [K MODELIROVANIIU TURBULENTNYKH POGRANICHNYKH SLOEV]
V. T. MOVCHAN Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 11-16. In Russian. refs
Copyright

Different turbulence models are compared in the case of low turbulence, when their predictions are practically equivalent. A comparison of the different formulas for the turbulent viscosity coefficient, yields information on the kinetic energy of turbulence and dissipation rate near the wall at small Reynolds numbers; it also makes it possible to refine turbulence hypotheses of differential models. Approximate analytical expressions for the kinetic energy of turbulence and its dissipation rate near the wall are obtained. V.L.

A91-17103
CALCULATION OF FLOW PAST WINGS WITH ALLOWANCE FOR FLOW SEPARATION USING A NONVISCOUS GAS MODEL [O RASCHETE OBTEKANIIA KRYL'EV S UCHETOM OTRYVA POTOKA V RAMKAKH MODELI NEVIAZKOGO GAZA]
A. P. SHASHKIN Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 16-19. In Russian. refs
Copyright

An approach to the calculation of flow past wings at high Reynolds numbers is proposed which is based on a nonviscous gas model. It is shown that a solution obtained in the framework of the nonviscous gas model can be qualitatively consistent with

a solution to the Navier-Stokes equations near the boundary if the possibility that the coefficients y(k/2) do not become zero is taken into account in the approximation of the boundary conditions at the wall. The approach proposed here makes it possible to consider microseparation while still remaining within the confines of the nonviscous gas model. V.L.

A91-17104
NUMERICAL MODELING OF VISCOUS EFFECTS IN THE ANALYSIS OF THREE-DIMENSIONAL FLOW IN TURBOMACHINE CASCADES [CHISLENNOE MODELIROVANIE EFFEKTOV VIAZKOSTI PRI RASCHETE PROSTRANSTVENNOGO TECHENIIA V RESHETKAKH TURBOMASHIN]
M. L. UGRIUMOV and IU. A. SKOB Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 20-25. In Russian.
Copyright
Adiabatic gas flow in the blade passage of a turbomachine is calculated using a scheme of viscous-nonviscous interaction between the boundary layer and the nonviscous flow core. The approach allows for intense mass and energy transfer between the viscous and nonviscous flow layers along the characteristic boundary layer lines. Flow in the region of interest is described by systems of equations of an ideal gas, three-dimensional boundary layer, interaction conditions, and relations at discontinuities. The principal flow characteristics are determined by using Euler equations. The approach proposed here has been implemented in software written in PL/1. V.L.

A91-17107
CONSIDERATION OF A VELOCITY DEFECT IN THE WAKE OF A ROTOR BLADE IN THE CALCULATION OF AN AXIAL-FLOW COMPRESSOR STAGE UNDER PRESTALL CONDITIONS [UCHET DEFEKTA SKOROSTI ZA RABOCHIMI LOPATKAMI PRI RASCHETE STUPENI OSEVOGO KOMPRESSORA NA PREDSRYVNYKH REZHIMAKH]
V. A. KOVAL' and V. I. KOVALEV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 33-36. In Russian.
Copyright
The problem of determining the form of flow in the wake of axial-flow compressor rotors under prestall conditions is solved analytically using reduced closure relations for a three-dimensional turbulent wake. It is emphasized that the analytically determined axial velocity curve is essential for obtaining criteria describing the stall limit of a blade row and for the correct calculation of flow parameters in the subsequent stages of a multiple-stage compressor. V.L.

A91-17108
FLOW CONTROL IN THE TRANSITION DUCT OF A TWO-STAGE COMPRESSOR [UPRAVLENIE TECHENIEM V PEREKHODNOM KANALE DVUKHKASKADNOGO KOMPRESSORA]
A. F. BREKHOV and L. N. BUSLIK Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 37-40. In Russian.
Copyright
Experimental results on the effect of the circumferential angle of the guide vanes on the aerodynamic characteristics of the axisymmetric annular transition duct of a two-stage compressor are presented and analyzed. It is shown, in particular, that tilted quide vanes reduce the boundary layer thickness and flow separation effects. This leads to a reduction of mechanical losses in the transition duct. V.L.

A91-17112
A STUDY OF THE EFFECT OF FLIGHT CONDITIONS AND MAIN AIRCRAFT PARAMETERS ON THE THRUST-WEIGHT RATIO REQUIREMENTS OF SECOND-GENERATION SUPERSONIC PASSENGER AIRCRAFT AT THE SUPERSONIC STAGE OF THE ACCELERATING CLIMB [ISSLEDOVANIE VLIIANIIA REZHIMOV POLETA I OSNOVNYKH PARAMETROV SAMOLETA NA POTREBNUIU TIAGOVOORUZHENNOST' SVERKHZVUKOVOGO PASSAZHIRSKOGO SAMOLETA VTOROGO POKOLENIIA NA SVERKHZVUKOVOM UCHASTKE POD'EMA S RAZGONOM]
A. I. STARINA and T. P. STEBENEVA Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 52-55. In Russian.
Copyright
Thrust-weight ratio requirements during the supersonic stage of the accelerating climb are calculated over the Mach range 1.2-2.0 for a hypothetical second-generation supersonic passenger aircraft with a flying weight of 1770-3140 kN. Based on the results obtained, critical conditions are determined for the supersonic climb stage corresponding to the highest required thrust-weight ratio. It is shown that the required thrust-weight ratio can be minimized by optimizing the principal aircraft parameters and flight conditions and using such methods as optimizing the jet vector deflection. V.L.

A91-17113
A STUDY OF THE EFFECT OF FLIGHT CONDITIONS AND MAIN AIRCRAFT PARAMETERS ON THE FLIGHT VALUES OF THE LIFT-DRAG RATIO AND LIFTING FORCE OF SECOND-GENERATION SUPERSONIC PASSENGER AIRCRAFT AT THE SUPERSONIC STAGE OF THE ACCELERATING CLIMB [ISSLEDOVANIE VLIIANIIA REZHIMOV POLETA I OSNOVNYKH PARAMETROV SAMOLETA NA POLETNYE ZNACHENIIA AERODINAMICHESKOGO KACHESTVA I POD'EMNOI SILY SVERKHZVUKOVOGO PASSAZHIRSKOGO SAMOLETA VTOROGO POKOLENIIA NA SVERKHZVUKOVOM UCHASTKE POD'EMA S RAZGONOM]
A. I. STARINA and T. P. STEBENEVA Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 56-59. In Russian.
Copyright
The effect of flight conditions and aircraft parameters on the degree to which the aerodynamic potential of the aircraft is realized during the supersonic accelerating climb is investigated analytically for a hypothetical second-generation supersonic passenger aircraft with a take-off weight of 2700 kN with a cruising speed of M 2-2.2. It is shown that specific wing loading can be selected in such a way that the flight lift-drag ratio and the lift coefficient would equal 1, thus ensuring a maximum lift-drag ratio during the flight. Under these conditions, the specific wing load would depend only slightly on the longitudinal acceleration in the range considered (0-0.075) but would change noticeably with the flying weight and permissible sonic boom intensity on the ground. V.L.

A91-17175
CRITICAL REGIMES OF THE TURBINE FLOW PATH AT HIGH VELOCITIES [PROBLEMY KRIZISNYKH REZHIMOV V PROTOCHNYKH CHASTIAKH TURBIN PRI BOL'SHIKH SKOROSTIAKH]
M. E. DEICH, A. A. TISHCHENKO, A. P. SHCHERBAKOV, and S. A. DAMAZH Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Sept.-Oct. 1990, p. 108-124. In Russian. refs
Copyright
Experimental investigations of the flow structure and gasdynamic characteristics of turbine cascades provide evidence of a critical increase in static pressure fluctuations in individual nozzle cascades at transonic velocities. It is shown that the transonic crisis, which involves an abrupt increase in losses, does not occur in the presence of a downstream perturbation source. A hypothesis concerning the mechanism of the critical regimes

observed at transonic and supersonic velocities is proposed and supported by experimental data. V.L.

A91-17210* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF POWERED-LIFT FLOWS
WILLIAM R. VAN DALSEM, KALPANA CHAWLA, MERRITT H. SMITH (NASA, Ames Research Center, Moffett Field, CA), and PATRICIA A. ABELOFF (Colorado, University, Boulder) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 165-181. refs
Copyright

This article presents work performed at NASA Ames involving the application of computational fluid dynamics (CFD) to the prediction of flows encountered by powered-lift aircraft operating in ground effect. These flows are characterized by jet and jet-induced flows interacting with the ground and aerodynamic surfaces. Over the last five years, work has progressed from simulating the interaction of a single jet impacting on a ground plane, through the simulation of a delta planform with multiple jets in ground effect, to an ongoing effort to simulate the complete flow about a Harrier AV-8B in ground effect. Efforts have also been made to predict the thermal interaction between hot propulsive jets and a landing surface of arbitrary thermal properties. Progress to data in each of these areas is outlined. Author

A91-17239
TILTROTOR AERODYNAMIC BLADE DESIGN BY NUMERICAL OPTIMIZATION METHOD
JOHN LIU, DAVID J. PAISLEY (Boeing Helicopters, Philadelphia, PA), and J. HIRSH (Boeing Computer Services, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 557-567. refs
Copyright

A formal procedure for automating the aerodynamic design optimization of tiltrotor blades is discussed. An approach is taken to couple an axial flow blade-element momentum hover/cruise analysis program with a general purpose numerical optimization algorithm. The resulting optimization environment performs the systematic evaluation of the rotor blade design variables to converge on a best compromise that meets the desired hover/cruise goal and requirements. The numerical optimization system is applied to optimize the twist, chord, and airfoil distributions of a current tiltrotor blade in order to obtain an improvement in hover efficiency without causing a penalty in cruise efficiency. The resulting optimized rotor performs significantly better in hover as well as in cruise. Details of the proper formulation of the automatic blade design procedure are discussed. Author

A91-17258
AERODYNAMIC RESULTS OF A PRESSURE-INSTRUMENTED MODEL ROTOR TEST AT THE DNW
PETER F. LORBER (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 743-756. Research supported by United Technologies Corp. and U.S. Army. refs
Copyright

Extensive airload measurements have been obtained during wind tunnel testing of a pressure-instrumented model of the UH-60A Black Hawk helicopter main rotor. The test included level flight, descent and hover conditions, and was conducted at the Duits Nederlands Windtunnel as part of a joint acoustics and aerodynamics program by the Army Aeroflightdynamics Directorate, NASA, United Technologies Research Center and Sikorsky Aircraft. The combination of the variety of measurements (blade pressures, acoustics, dynamics, and performance), the density of measurement stations, and the number and range of test conditions resulted in the most comprehensive model rotor test yet conducted. This paper describes the model and discusses the aerodynamic results. The blade pressures and integrated airloads are examined to identify regions of wake interaction, supersonic flow, negative loading, and flow separation. For descent conditions, the radial and azimuthal locations of impulsive loading events related to blade-vortex interaction noise are determined and compared with predictions. Supersonic flow regions are examined in terms of their potential for generating high speed impulsive noise. Author

A91-17259
DIRECT PERIODIC SOLUTIONS OF ROTOR FREE WAKE CALCULATIONS BY INVERSION OF A LINEAR PERIODIC SYSTEM
WAYNE O. MILLER and DONALD B. BLISS (Duke University, Durham, NC) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 757-769. Research supported by the U.S. Army. refs
Copyright

The 'periodic inversion' approach to the calculation of helicopter rotor free wakes not only guarantees periodically steady-state solutions, but offers the means with which to solve for wake dynamics at all advance ratios, including hover and the lowest speeds. The method proceeds by enforcing periodic boundary conditions over 1/B of a rotor revolution, where B is the number of blades; the governing equations are written in a linear perturbation form, and the problem is written as a large linear system which is inverted for the perturbative correction. The method allows converged solutions to be found without the application of artificial damping, as is presently demonstrated for the case of the low speed wake structure. O.C.

A91-17260* McDonnell-Douglas Helicopter Co., Mesa, AZ.
AN ASSESSMENT OF FULL POTENTIAL AND EULER SOLUTIONS FOR SELF-GENERATED ROTOR BLADE-VORTEX INTERACTIONS
A. A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ), C. TUNG (NASA, Ames Research Center, Moffett Field, CA), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 771-784. Research supported by McDonnell Douglas Helicopter Co. refs
(Contract NAS1-17145; DAAL03-88-C-0003)
Copyright

An assessment is made of the accuracy and suitability of the three-dimensional full potential and Euler equations in the modeling of subcritical and supercritical rotor blade-vortex interactions (BVI). The interaction velocity fields are obtained through a nonlinear superposition of the rotor and the vortex wake flow fields. Vortex effects are simulated using the velocity 'transpiration' approach. A modified surface condition is prescribed and enforced at each time step of the computations to satisfy the tangency boundary condition. Potential blade-vortex encounters are identified and tracked in time at equal increments of rotor azimuth using the lifting-line helicopter/rotor trim code CAMRAD. This information is then utilized in interpolation routines within the flow solvers to compute the instantaneous position(s) of the interaction vortex element(s) with respect to the blade for the time-accurate calculations. Results for subcritical self-generated BVI and for supercritical interactions resulting from an upstream-generated vortex are presented. Author

A91-17262
COMPUTATION AND MEASUREMENT OF THE FLOWFIELD NEAR A SWEPT ROTOR BLADE TIP IN HOVER
FU-LIN TSUNG, SHIUH-GUANG LIOU, NARAYANAN M. KOMERATH, and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 797-807. refs
(Contract DAAG29-88-C-0003)
Copyright

Navier-Stokes computations of the flowfield and surface pressure distribution are described for a rotor bade with a complex

tip shape. The flowfield is also studied experimentally using laser sheet flow visualization, and measured in detail using laser Doppler velocimetry. The objective of this research is to understand the behavior of the flow over rotor tip shapes for use at high pitch angles, and to develop methods of improving retreating-blade performance in forward flight. Comparison of the computed results with results for a fixed wing show that the vortex system around the rotor tip is less sensitive to pitch angle variation, and remains organized at high pitch angles. Fairly good agreement is obtained between computed and measured velocity fields in the tip region, with the wake computation replaced by a simple pitch angle correction. There is no strong inboard vortex observed in either the computed or measured results. Author

A91-17263
RESULTS OF WAKE SURVEYS ON ADVANCED ROTOR PLANFORMS
G. CARLIN and K. FARRANCE (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 809-815. refs
Copyright

The results of an experimental investigation of wake surveys on advanced rotor planforms are presented. An unobtrusive seven-hole pressure probe was used to survey wake data. A system of six probes affixed to a traverse was used. Care was taken to make comparisons of wake data at equivalent lift levels. Plots of force and moment data, velocity vector and vortex intensity are presented. The test resulted in the compilation of a large data base from which analytical methods can be judged. Author

A91-17288* Maryland Univ., College Park.
THEORETICAL AND EXPERIMENTAL STUDY OF UNSTEADY ROTOR/BODY AERODYNAMIC INTERACTIONS
G. L. CROUSE, J. G. LEISHMAN, and NAIPEI BI (Maryland, University, College Park) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1075-1087. Research supported by the University of Maryland. refs
(Contract DAAL03-88-C-0002; NAG2-607)
Copyright

A systematic study is made of the unsteady interactions between a rotor and a body in order to assess the degree of sophistication necessary to accurately predict the unsteady pressure signatures on a helicopter fuselage due to the rotor and its wake. Experimental measurements and theoretical calculations were both made in order to clarify the nature of the unsteady interactions and to define the limitations of potential flow theory in modeling the various phenomena. An attempt is made to accurately model the geometry of vortex/surface interactions as well as to include the appropriate unsteady terms in the analysis. Unsteady pressure measurements from a series of wind tunnel experiments are also provided. Such data has allowed new conlusions on the nature of body pressure signatures which are due to blade passage effects, close wake interactions, and wake inmpingement on the fuselage. It is also concluded that the flowfield about the body is highly unsteady and cannot be modeled without the inclusion of the unsteady terms in the calculation of the local surface pressures and that theoretical modeling is still possible over most of the flow field using an unsteady inviscid analysis. L.K.S.

A91-17289* Textron Bell Helicopter, Fort Worth, TX.
APPLICATION OF A NEW NAVIER-STOKES INVERSE METHOD TO THE DESIGN OF ADVANCED AIRFOILS
J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX), J. B. MALONE (NASA, Langley Research Center, Hampton, VA), and R. VERMELAND (Cray Research, Inc., Mendota Heights, MN) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1089-1098. refs
Copyright

A new inverse airfoil design method has been developed. This method couples a two-dimensional Navier-Stokes code to a residual-correction design algorithm to produce an efficient design code. Since this method can be used to design airfoils near the limits of performance capabilities, a technique to investigate the limits of lift has been developed to guide the design of new airfoils. Examples of the use of the inverse Navier-Stokes code and the maximum lift technology in the design of new airfoils are presented. Author

A91-17290
NEW VORTEX/SURFACE INTERACTION METHODS FOR THE PREDICTION OF WAKE-INDUCED AIRFRAME LOADS
T. R. QUACKENBUSH, C.-M. G. LAM (Continuum Dynamics, Inc., Princeton, NJ), D. B. BLISS, and A. KATZ (Duke University, Durham, NC) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1099-1110. Research supported by the U.S. Army. refs
Copyright

The status of work on a unified, consistent model of wake/airframe interaction is described. The model incorporates a variety of recently-developed tools for the analysis of vortex dynamics and vortex/surface interaction, including a full-span free wake model of the rotor coupled to a panelled body, as well as new methods for the prediction of surface pressures due to close vortex interactions based on analytical numerical matching. Correlation studies with measured rotor flow fields are presented that establish the success of the free wake model in capturing flow fields near rotor/body combinations. Also, model problems are solved to demonstrate the ability of the methods under development to predict inviscid vortex/surface interactions accurately and with greater efficiency than traditional methods. Finally, fundamental studies of curved filament dynamics near a flat surface are described, studies which are intended to guide the modeling of vortex behavior near the body in the free wake calculation as well as to provide a framework for the study of viscous effects. The fundamental conclusion is that the analytical and computational tools developed here represent several of the key components for a unified model of rotorcraft interactional aerodynamics. Author

A91-17291* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INFLOW VELOCITY PERTURBATIONS DUE TO FUSELAGE EFFECTS IN THE PRESENCE OF A FULLY INTERACTIVE WAKE
JOHN D. BERRY and SUSAN L. ALTHOFF (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1111-1120. refs
Copyright

The velocity field at locations above the plane of the rotor disk of a generic helicopter configuration has been measured experimentally and modeled using two computational models. The first computational model represents only the portion of the velocity field due to the fuselage, using only the potential due to freestream onset flow. The second model represents all elements of the problem in an incompressible field: the rotor, the rotor wake, and the non-lifting fuselage. The first model is used to assess the fidelity requirement for fuselage paneling. Comparisons are made between a much simplified body shape, an accurate body shape, a body shape with a crude hub/shaft model and wind-tunnel measurements. The second model is used to assess the relative magnitude of the velocity perturbations at the rotor disk due to the effects of the fuselage. A fully interactive time-stepping wake method is used to predict the velocities at the rotor disk. These velocities are computed with and without the fuselage in the model and compared with measured wind-tunnel inflow velocities. The difference between the velocities computed with and without the fuselage is then compared with the perturbation velocity field computed by the first method. Author

A91-17292
SYSTEMATIC CORRELATION AND EVALUATION OF THE EHPIC HOVER ANALYSIS
JOHN P. SHANLEY, ROBERT C. MOFFITT, and S. JON DAVIS (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1121-1134. refs
Copyright
A study is conducted which seeks to track the ability of free wake analyses to predict test results for a wide range of rotor geometries while adhering to a single, consistent set of guidelines for program input. It is determined that correlation of all rotors in this data base is good, with the exception of the older technology, low twist, six bladed rotors. It is suggested that the poor showing of these rotors may be due to the effect of exposed anti-abrasion strips and an observed oscillatory wake interference phenomenon. L.K.S.

A91-17297* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF THE WIDE-FIELD SHADOWGRAPH TECHNIQUE TO HELICOPTERS IN FORWARD FLIGHT
JEFFREY S. LIGHT, THOMAS R. NORMAN (NASA, Ames Research Center, Moffett Field, CA), and ALEXANDRA A. FRERKING (Sterling Federal Systems, Inc., Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1207-1220. refs
Copyright
A test was conducted to examine the feasibility of using the wide-field shadowgraph method for visualizing the wake of a small-scale helicopter rotor in forward flight. A wide range of test conditions were examined, including thrust and forward speed variations. Shadowgraphs from the side and top of the rotor were obtained. The visibility of the tip vortices using the shadowgraph method was documented for advance ratios up to 0.175. It was demonstrated that shadowgraphs of the rotor wake in forward flight can be used to obtain qualitative and quantitative information about wake geometry, wake/body interactions, and blade/vortex interactions. Video cameras were used for the first time to record the shadowgraphs. These provided several advantages compared to still cameras and greatly enhanced the capabilities of the shadowgraph method. Author

A91-17299* Army Aviation Systems Command, Moffett Field, CA.
AERODYNAMIC AND ACOUSTIC TEST OF A UNITED TECHNOLOGIES MODEL SCALE ROTOR AT DNW
YUNG H. YU, SANDY R. LIU (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), DAVE E. JORDAN (NASA, Ames Research Center, Moffett Field, CA), ANTON J. LANDGREBE, PETER F. LORBER (United Technologies Research Center, East Hartford, CT), MICHAEL J. POLLACK (Sikorsky Aircraft, Stratford, CT), and RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1233-1250. refs
Copyright
The UTC model scale rotors, the DNW wind tunnel, the AFDD rotary wing test stand, the UTRC and AFDD aerodynamic and acoustic data acquisition systems, and the scope of test matrices are discussed and an introduction to the test results is provided. It is pointed out that a comprehensive aero/acoustic database of several configurations of the UTC scaled model rotor has been created. The data is expected to improve understanding of rotor aerodynamics, acoustics, and dynamics, and lead to enhanced analytical methodology and design capabilities for the next generation of rotorcraft. L.K.S.

A91-17373
INFLUENCE OF THE ENTROPY LAYER ON VISCOUS HYPERSONIC INTERACTION SCALES [INFLUENCE DE LA COUCHE D'ENTROPIE SUR L'ECHELLE DE LA REGION SEPAREE EN AERODYNAMIQUE HYPERSONIQUE]
PIERRE-YVES LAGREE (Paris VI, Universite, France) Academie des Sciences, Comptes Rendus, Serie II, Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 311, no. 10, Nov. 8, 1990, p. 1129-1134. In French. refs
Copyright
Viscous hypersonic interaction is examined within the framework of the triple deck theory, with the upper deck considered to lie in the entropy layer. The thickness of the upper deck is selected to be exactly the same as that of the entropy layer. The nose bluntness is accounted for by altering the usual scales. R.E.P.

A91-17596
SOLVING THE NAVIER-STOKES EQUATIONS ON THE ETA-10 FOR VORTEX FLOW AROUND A DELTA WING
ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton, England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 27-41. refs
Copyright
The large-scale Navier-Stokes simulations of transonic flows around a 65-deg-sweep delta wing with a round leading edge are presented for both low and high angles of attack and compared with large-scale Euler solutions. The viscous results for the angle of attack of 2 deg reveal the presence of a laminar separation bubble along the leading edge. At the higher angle of attack of 20 deg, the Navier-Stokes solution does not display the vortex splitting showed by the Euler solution, but instead it indicates the separation of the boundary layer; this agrees better with experimental results. The agreement between measurements and the Navier-Stokes solution is not as good for a 24-deg breakdown, although it is still better than the comparison with the Euler results. V.T.

A91-17597
SOME EXPERIENCES OF COMPUTATIONAL AERODYNAMICS ON HIGHLY PARALLEL PROCESSORS
C. H. LAI (Queen Mary College, London, England) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton, England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 43-55. refs
Copyright
The paper summarizes some experiences in solving aeronautical fluid-dynamics problems on highly parallel processors and demonstrates how panel methods can be implemented on these processors. Basic parallel iteration techniques are discussed, along with the application to the elliptic equation through finite-difference discretization. Methods for solving steady transonic flows governed by an approximation in accordance with the small-perturbation theory are covered, and attention is focused on crinkled and sliced mapping, domain decomposition, and parallel shock capturing. The efficiency and space complexity of an orthogonalization method for the solution of a dense matrix equation resulting from a panel method are discussed and compared with those of the Gauss-Jordan elimination method. V.T.

A91-17598
ANALYSIS OF TRANSONIC FLOW AROUND ISOLATED NACELLES AT INCIDENCE ON THE IBM 3090 VF
SEN-MING CHANG (IBM Applications Technology Center, Kingston, NY) and JOHN T. SPYROPOULOS (Purdue University, Indianapolis, IN) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton,

England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 57-66. refs
Copyright

This paper describes the application of block-structured finite element grid generation and Euler solution schemes to the solution of flows around isolated nacelles at incidence. These schemes were implemented at the IBM Kingston NIC Center on an IBM 3090-400VF supercomputer employing four processors and four vector facilities. A dynamic load-balanced distributing mechanism based on the VS FORTRAN Multitasking Facility (MTF) was applied to the Euler equation solver. Both implementation detail and performance data will be included in this paper. Author

A91-17600
A PARALLEL NUMERICAL SIMULATION FOR SUPERSONIC FLOWS USING ZONAL OVERLAPPED GRIDS AND LOCAL TIME STEPS FOR COMMON AND DISTRIBUTED MEMORY MULTIPROCESSORS
M. R. PATEL, W. B. STUREK (U.S. Army, Ballistics Research Laboratory, Aberdeen Proving Ground, MD), and R. E. HIROMOTO (Los Alamos National Laboratory, NM) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton, England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 89-104. refs
Copyright

Parallel Navier-Stokes codes are developed to solve both two-dimensional and three-dimensional flow fields in and around ramjet and nose tip configurations. A multi-zone overlapped grid technique is used to extend an explicit finite difference method to more complicated geometries. Parallel implementations are developed for execution on both distributed and common memory multiprocessor architecture. For the steady state solutions, the use of the local time-step method has the inherent advantage of reducing the communications overhead commonly incurred by parallel implementations. Computational results of the codes are given for a series of test problems. The parallel partitioning of computational zones is also discussed. Author

A91-17625
COMPUTATION OF DOWNSTREAM FLOW ANGLES AND LOSSES FOR SUB- AND TRANSONIC TURBINE CASCADES FLOWS [BERECHNUNG DER ABSTROEMWINKEL AND VERLUSTE BEI SUB- UND TRANSSONISCH DURCHSTROEMTEN TURBINENGITTERN]
P.-A. GIESS (DLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) VDI-Forschungsheft (ISSN 0015-7899), no. 657, p. 1-48. In German. refs
Copyright

A time-marching procedure solving the instationary Euler equations to compute two-dimensional transonic flows through plane cascades has been investigated. Considering the time dependent development of flow quantities as well as the spatial discretization of the flow field, the numerical solution's state of convergence is determined. From this some criteria are derived to get well-based statements on convergence and to choose the grid best suited for a minimum computing time. From this inviscid solution the overall loss coefficient can be determined, computing the main contributions separately. These are the losses due to the blade boundary layer, the trailing-edge flow, and those due to shocks and mixing within the flowfield. Author

A91-17644#
AN EXPERIMENTAL INVESTIGATION OF ROTOR BLADE AIRLOADS AND WAKE STRUCTURE AT HIGH ADVANCE RATIO
T. L. WOOD, A. G. BRAND (Bell Helicopter Textron, Inc., Fort Worth, TX), and J. W. ELLIOTT (U.S. Army, Aerostructures Directorate, Hampton, VA) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 14 p. refs

A four-bladed bearingless soft-inplane rotor is tested in a subsonic wind tunnel in order to study airloads and wake structure at a high advance ratio. The data acquired include rotor performance, blade loads, blade pressure measurements, inflow maps, and velocity measurements in the wake of the rotor. A program capable of six degree-of-freedom flight simulations as well as wind-tunnel simulations is used to provide analytical predictions for comparison with the wind-tunnel data. It is observed that the rotor inflow region has significant unsteady velocity fluctuations relative to the mean induced velocity. It is pointed out that the extent of the mean induced upflow region is underpredicted by the program, but the trends observed in an experimental mean inflow velocity map are confirmed. V.T.

A91-17646*# Advanced Rotorcraft Technology, Inc., Mountain View, CA.
ESTIMATION OF UH-60 BLADE AERODYNAMIC LOADS AND ROTOR IMPEDANCE USING GENERALIZED STRAIN PATTERN/KALMAN FILTER APPROACH
OFER BRUHIS, RONALD W. DUVAL (Advanced Rotorcraft Technology, Inc., Mountain View, CA), and MOSHE IDAN (Stanford University, CA) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 13 p. refs
(Contract NAS2-12915)

The purpose of the study is to develop and verify a methodology capable of predicting the vibration levels and estimating the aerodynamic loads and rotor impedance of a rotorcraft blade. Simulated flight test data is generated, blade airloads and elastic hub motions are estimated from the simulated data through the use of the Kalman filter/smoother, simulation upgrading and parameter identification are performed, and the ability to identify rotor impedance from a simulation by isolating the rotor model and providing a prescribed motion for the hub as rotor excitation is demonstrated. It is pointed out that the statistical estimation procedure utilized in the proposed methodology minimizes the impact of sensor noise, truncation error, and instrumentation bias on the results. V.T.

A91-17657* University Coll., London (England).
INVISCID-VISCOUS INTERACTION ON TRIPLE-DECK SCALES IN A HYPERSONIC FLOW WITH STRONG WALL COOLING
S. N. BROWN (University College, London, England), H. K. CHENG, and C. J. LEE (Southern California, University, Los Angeles, CA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 220, Nov. 1990, p. 309-337. refs
(Contract NAGW-1061; AF-AFOSR-88-0146)
Copyright

The influence of wall temperatures on the flow structure in a region near a laminar separation is presently studied on the triple-deck scales, for the case of a high supersonic flow's inviscid-viscous interactions. A critical wall-temperature range is identified whose lower deck pressure-displacement relation departs from that of the classical formulation; below it, the pressure-displacement relation undergoes still greater transformations in conjunction with drastic scale-changes in the triple deck. The reduced lower-deck problem falls into supercritical, transcritical, and subcritical domains. A computational study is conducted for the compressive free-interaction solutions, and solutions are obtained for a sharp-corner ramp in the three wall-temperature ranges. O.C.

A91-17658* California Univ., Los Angeles.
THE COMPRESSIBLE VORTEX PAIR
S. D. HEISTER, J. M. MCDONOUGH, A. R. KARAGOZIAN, and D. W. JENKINS (California, University, Los Angeles) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 220, Nov. 1990, p. 339-354. refs
(Contract NCC2-374)
Copyright

A numerical solution for the flow field associated with a compressible pair of counter-rotating vortices is developed. The

compressible, two-dimensional potential equation is solved utilizing the numerical method of Osher et al. (1985) for flow regions in which a non-zero density exists. Close to the vortex centers, vacuum 'cores' develop owing to the existence of a maximum achievable flow speed in a compressible flow field. A special treatment is required to represent these vacuum cores. Typical streamline patterns and core boundaries are obtained for upstream Mach numbers as high as 0.3, and the formation of weak shocks, predicted by Moore and Pullin (1987), is observed. Author

A91-18051
STING CORRECTIONS TO ZERO-LIFT DRAG OF AXISYMMETRIC BODIES IN TRANSONIC FLOW
P. R. VISWANATH and G. RAJENDRA (National Aeronautical Laboratory, Bangalore, India) Aeronautical Journal (ISSN 0001-9240), vol. 94, Oct. 1990, p. 279-288. refs
Copyright

Experiments at transonic speeds have been performed on several boat-tailed afterbodies and sting combinations with a view to assessing sting corrections to the measured afterbody drag at transonic speeds. Measurements made included afterbody total drag and base pressure in the Mach number range of 0.6-1.0 and Reynolds number range (8-9.5) x 10 to the 6th. Correlations of base pressure and boat-tail pressure drag for the sting diameter and flare effects have been proposed using dimensional arguments. The correlations provide quick and reliable estimates for corrections that can be applied to the measured zero-lift drag of axisymmetric bodies with either contoured or conical boat-tailing. Author

A91-18068#
GROWTH AND DECAY OF VORTEX STREET IN THE WAKE OF A TWO-DIMENSIONAL BODY
MUNESHIGE OKUDE, KUNIHISA WADA, and TATSUYA MATSUI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 441, 1990, p. 533-540. In Japanese, with abstract in English. refs

The correlation between the streak line patterns visualized and the results obtained by a hot-wire probe was investigated in the wakes both behind a circular cylinder and a flat plate at zero incidence in a low-speed wind tunnel. When a smoke wire is set in a section of a vortex street, the pattern of streak lines shows the vortex street if the circulation of each vortex is strong enough. If the circulation is weak, then the streak line pattern does not show the vortex street, but shows only wavy streak lines. The patterns of streak lines for both cases of a circular cylinder and a flat plate seem to show the downstream increase in the size of vortices. However, the vorticity of a vortex in the wake of a circular cylinder diffuses into the surroundings and its circulation decreases downstream. The vorticity in the wake of a flat plate concentrates gradually so that vortices are formed and their circulations increase for some downstream distance. Author

A91-18225* Boeing Computer Services Co., Seattle, WA.
GLOBAL CONVERGENCE OF INEXACT NEWTON METHODS FOR TRANSONIC FLOW
DAVID P. YOUNG, ROBIN G. MELVIN, MICHAEL B. BIETERMAN (Boeing Computer Services, Seattle, WA), FORRESTER T. JOHNSON, and SATISH S. SAMANT (Boeing Commercial Airplanes, Seattle, WA) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 11, Dec. 1990, p. 1075-1095. refs
(Contract NSF ASC-85-19353; NAS2-12513)
Copyright

In computational fluid dynamics, nonlinear differential equations are essential to represent important effects such as shock waves in transonic flow. Discretized versions of these nonlinear equations are solved using iterative methods. In this paper an inexact Newton method using the GMRES algorithm of Saad and Schultz is examined in the context of the full potential equation of aerodynamics. In this setting, reliable and efficient convergence of Newton methods is difficult to achieve. A poor initial solution guess often leads to divergence or very slow convergence. This paper examines several possible solutions to these problems, including a standard local damping strategy for Newton's method and two continuation methods, one of which utilizes interpolation from a coarse grid solution to obtain the initial guess on a finer grid. It is shown that the continuation methods can be used to augment the local damping strategy to achieve convergence for difficult transonic flow problems. These include simple wings with shock waves as well as problems involving engine power effects. These latter cases are modeled using the assumption that each exhaust plume is isentropic but has a different total pressure and/or temperature than the freestream. Author

A91-18251*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NAVIER-STOKES SOLUTIONS ABOUT THE F/A-18 FOREBODY-LEADING-EDGE EXTENSION CONFIGURATION
FARHAD GHAFFARI, JAMES M. LUCKRING, JAMES L. THOMAS (NASA, Langley Research Center, Hampton, VA), and BRENT L. BATES (Vigyan, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 737-748. Previously cited in issue 09, p. 1279, Accession no. A89-25285. refs
(Contract NAS1-17919)
Copyright

A91-18254*# Planning Research Corp., Hampton, VA.
SUPERSONIC FAR-FIELD BOUNDARY CONDITIONS FOR TRANSONIC SMALL-DISTURBANCE THEORY
MICHAEL D. GIBBONS (Planning Research Corp., Hampton, VA) and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 764-770. Previously cited in issue 12, p. 1775, Accession no. A89-30765. refs
Copyright

A91-18256#
EXPERIMENTAL STUDY OF ROTOR/BODY AERODYNAMIC INTERACTIONS
NAI-PEI BI and GORDON LEISHMAN (Maryland, University, College Park) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 779-788. Previously cited in issue 21, p. 3251, Accession no. A89-47668. refs
(Contract DAAL03-88-C-0002)
Copyright

A91-18259*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IDEAL EFFICIENCY OF PROPELLERS - THEODORSEN REVISITED
H. S. RIBNER (NASA, Langley Research Center, Hampton, VA) and S. P. FOSTER (Toronto, University, Downsview, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 810-819. Research supported by NSERC. refs
Copyright

Theodorsen's 1948 analog evaluation of the parameters governing the ideal (friction-free) efficiency of propellers is updated and extended by computer. The results are presented both in his format and in a much more convenient one by Kramer that avoids iteration: curves of power coefficient at constant ideal efficiency are plotted vs propeller advance coefficient. The curves for a wide range of blade numbers are collapsed into just three sets (with some approximation) by use of multiple, shifted (and distorted) abscissae scales. Along with an overview of Theodorsen's theory, analytic asymptotic results at low and high advance coefficients are given. At the low end, the disagreement with actuator disk theory is given support and physical interpretation. At the high end, exact agreement is found with the thrust of a slender twisted delta propeller. Author

A91-18260#
STATIC AEROELASTIC ANALYSIS OF FIGHTER AIRCRAFT USING A THREE-DIMENSIONAL NAVIER-STOKES ALGORITHM
DAVID M. SCHUSTER (Georgia Institute of Technology, Atlanta), JOSEPH VADYAK, and ESSAM ATTA (Lockheed Aeronautical

Systems Co., Burbank, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 820-825. Previously cited in issue 06, p. 759, Accession no. A90-19845. refs
(Contract F33615-87-C-3209)
Copyright

A91-18263#
EFFECT OF A SINGLE STRAKE ON THE FOREBODY VORTEX ASYMMETRY
T. TERRY NG (Eidetics International, Inc., Torrance, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 844-846.
Copyright

A small strake was placed near the apex along the leeward axis of a tangent-ogive forebody so that the interaction between the two vortices in this region is reduced. An experimental comparison has been made of flows with and without the strake. The results obtained demonstrate the importance of that flow at a small region near the apex which forms the vortex core; this region's flow is highly three-dimensional in nature, and strongly influenced by the axial flow in most situations. It is therefore accurately simulated by neither the impulsive flow analogy nor the conical flow assumption. O.C.

A91-18362*
AIRLOADS AND WAKE MODELS FOR A COMPREHENSIVE HELICOPTER ANALYSIS
WAYNE JOHNSON (Johnson Aeronautics, Palo Alto, CA) Vertica (ISSN 0360-5450), vol. 14, no. 3, 1990, p. 255-300. Research supported by the U.S. Army. Previously announced in STAR as N90-21738. refs
(Contract NAS2-11555)
Copyright

Fundamental considerations regarding the theory of modeling of rotary wing airloads, wakes, and aeroelasticity are presented. The topics covered are: airloads and wakes, including lifting-line theory, wake models and nonuniform inflow, free wake geometry, and blade-vortex interaction; aerodynamic and wake models for aeroelasticity, including two-dimensional unsteady aerodynamics and dynamic inflow; and airloads and structural dynamics, including comprehensive airload prediction programs. Results of calculations and correlations are presented. Author

A91-18363* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THREE-DIMENSIONAL VISCOUS ROTOR FLOW CALCULATIONS USING A VISCOUS-INVISCID INTERACTION APPROACH
CHING S. CHEN (NASA, Ames Research Center, Moffett Field, CA) and JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA) Vertica (ISSN 0360-5450), vol. 14, no. 3, 1990, p. 417-427. Previously announced in STAR as N90-19204. refs
Copyright

A three-dimensional viscous-inviscid interaction analysis was developed to predict the performance of rotors in hover and in forward flight at subsonic and transonic tip speeds. The analysis solves the full-potential and boundary-layer equations by finite-difference numerical procedures. Calculations were made for several different model rotor configurations. The results were compared with predictions from a two-dimensional integral method and with experimental data. The comparisons show good agreement between predictions and test data. Author

A91-18413* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AUTOMATED DOMAIN DECOMPOSITION FOR COMPUTATIONAL FLUID DYNAMICS
ALISON ANDREWS VOGEL (NASA, Ames Research Center, Moffett Field, CA) Computers and Fluids (ISSN 0045-7930), vol. 18, no. 4, 1990, p. 329-346. refs
Copyright

Automation of flow-field zoning in two-dimensions is an important step towards easing the three-dimensional grid generation bottleneck in computational fluid dynamics. A knowledge-based approach works well, but several aspects of flow-field zoning make the use of such an approach challenging. A proposed model and language to describe the process of zoning a flow field are presented, followed by a discussion of the implementation of EZGrid, a knowledge-based two-dimensional (2-D) flow-field zoner. Results are shown for representative two-dimensional aerodynamic configurations. Finally, an approach to the evaluation of flow-field zonings is described and used to compare the performance of EZGrid with that of a human expert. Author

A91-18414
A METHOD FOR REMOVING THE COORDINATE SINGULARITY ON BODIES WITH BLUNT ROUNDED NOSES AT INCIDENCE
TUNCER CEBECI, KALLE KAUPS (Douglas Aircraft Co., Long Beach, CA), and HSUN H. CHEN (California State University, Long Beach) Computers and Fluids (ISSN 0045-7930), vol. 18, no. 4, 1990, p. 369-389. refs
(Contract F49620-84-C-0007)
Copyright

A general method for calculating the boundary-layer development in the stagnation region of bodies with blunt rounded noses at incidence and with planes of symmetry is investigated. The three-dimensional equations are expressed in a nonorthogonal body-oriented coordinate system and appropriate transformations are devised for the line of symmetry equations to remove the singularity appearing in the metric coefficients and geodesic curvatures. A novel procedure based on a quasi-three-dimensional form of the equations and the characteristic box scheme is used to compute the initial conditions on a coordinate line off the line of symmetry. Sample calculations are reported on the line of symmetry for three shapes which include one typical of those found on ships with bulbous bows. Results are also presented for the nose region of a prolate spheroid at incidence and the solutions are compared with the previous solutions of Cebeci, Khattab and Stewartson. The results demonstrate that the method, with its essential transformations and solution procedures, represents the boundary-layer development accurately and can be used for axisymmetric and nonaxisymmetric bodies with blunt rounded noses. Author

A91-18599* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE ANALYSIS AND SIMULATION OF COMPRESSIBLE TURBULENCE
GORDON ERLEBACHER, M. Y. HUSSAINI, S. SARKAR (NASA, Langley Research Center; Institute for Computer Applications in Science and Engineering, Hampton, VA), and H. O. KREISS (California, University, Los Angeles) Theoretical and Computational Fluid Dynamics (ISSN 0935-4964), vol. 2, no. 2, 1990, p. 73-95. Previously announced in STAR as N90-22539. refs
Copyright

Compressible turbulent flows at low turbulent Mach numbers are considered. Contrary to the general belief that such flows are almost incompressible (i.e., the divergence of the velocity field remains small for all times), it is shown that even if the divergence of the initial velocity field is negligibly small, it can grow rapidly on a nondimensional time scale which is the inverse of the fluctuating Mach number. An asymptotic theory which enables one to obtain a description of the flow in terms of its divergence-free and vorticity-free components has been developed to solve the initial-value problem. As a result, the various types of low Mach number turbulent regimes have been classified with respect to the initial conditions. Formulae are derived that accurately predict the level of compressibility after the initial transients have disappeared. These results are verified by extensive direct numerical simulations of isotropic turbulence. Author

A91-18600* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON THE INVISCID ACOUSTIC-MODE INSTABILITY OF SUPERSONIC SHEAR FLOWS. I - TWO-DIMENSIONAL WAVES
LESLIE M. MACK (JPL, Pasadena, CA) Theoretical and Computational Fluid Dynamics (ISSN 0935-4964), vol. 2, no. 2, 1990, p. 97-123. refs
Copyright

The same previously utilized methods to study acoustic-mode instability in supersonic boundary layers are applied to free shear layers, and new calculations are derived for boundary layers with cooling and suction. The linear inviscid stability theory is employed to calculate spatial amplification rates at Mach 3 for the sinuous and varicose modes of a single wake flow and a single jet flow, each made up of the same mixing-layer profile plus a central region of uniform flow. It is shown that along with sequences of sinuous and varicose unstable modes clearly identifiable as acoustic modes, both of these flows, unlike the boundary layer, have a lowest sinuous mode that is the most unstable. R.E.P.

A91-18859
SOLUTION OF THE PROBLEM OF FLOW OF AN IDEAL FLUID NEAR THE APEXES OF BODIES AND WINGS [RESHENIE ZADACHI O TECHENII IDEAL'NOI ZHIDKOSTI V OKRESTNOSTI VERSHIN TEL I KRYL'EV]
A. V. VOEVODIN and G. G. SUDAKOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), May-June 1990, p. 60-65. In Russian. refs
Copyright

An algorithm for solving eigenvalue problems using the vortex frame and panel methods is proposed which makes it possible to determine the eigenvalues of the exponents and eigenfunctions of the problem. The application of the approach proposed here to problems of flow past a triangular wing apex and a circular cylindrical body apex (the problems are reduced to those of solving an ordinary differential equation) is illustrated by examples. The calculation results are compared with an exact solution. V.L.

A91-18860
THEORY OF A DEEP DYNAMIC STALL ON A WING [K TEORII GLUBOKOGO DINAMICHESKOGO SRYVA NA KRYLE]
G. I. TAGANOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), May-June 1990, p. 72-78. In Russian. refs
Copyright

An attempt is made to develop a theory for the hysteresis of the aerodynamic characteristics of an airfoil under conditions of deep dynamic stall which could explain experimental data reported in the literature. The starting point of the analysis is the theory of quasi-stationary flow past a wing or supercritical angles of attack. It is found that the dynamic hysteresis of the periodic airfoil oscillations under conditions of deep dynamic stall is largely due to a change in the geometry (displacement thickness) of the vortex wake. V.L.

A91-18901#
STABILITY SENSITIVITY STUDIES FOR SYNTHESIS OF AEROELASTIC SYSTEMS
YI LU and V. R. MURTHY (Syracuse University, NY) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 849, 850. refs
Copyright

A direct method is presented for performing sensitivity analyses of discrete aeroelastic systems in the Laplace transform domain. The method considers the unsteady aerodynamic forces without the augmented state variables, and yields the derivative of eigenvalues and eigenvectors simultaneously. The formulation involves only the eigenvalue and eigenvector under consideration. The relative effect of the system matrix elements can be obtained directly, thereby aiding in the adjustment of parameters to obtain a system of dynamic characteristics. Attention is given to the method's use in the sensitivity analysis of the dynamic characteristics of helicopter rotor blades in hover. O.C.

A91-18904*# Analytical Methods, Inc., Redmond, WA.
ZONAL APPROACH TO V/STOL AERODYNAMICS
SUNGYUL YOO and DANIEL J. STRASH (Analytical Methods, Inc., Redmond, WA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 866-872. Previously cited in issue 21, p. 3249, Accession no. A89-47634. refs
(Contract NAS2-12166)
Copyright

A91-18907*# Air Force Wright Research and Development Center, Wright-Patterson AFB, OH.
NUMERICAL SIMULATION OF AN F-16A AT ANGLE OF ATTACK
G. W. HUBAND, J. S. SHANG, and M. J. AFTOSMIS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 886-892. Research supported by USAF and NASA. Previously cited in issue 10, p. 1434, Accession no. A90-26911. refs

A91-18910*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
COMBINED EFFECTS OF NOSE BLUNTNESS AND SURFACE PERTURBATIONS ON ASYMMETRIC FLOW PAST SLENDER BODIES
C. A. MOSKOWITZ (Virginia Polytechnic Institute and State University, Blacksburg), R. M. HALL (NASA, Langley Research Center, Hampton, VA), and F. R. DEJARNETTE (North Carolina State University, Raleigh) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 909, 910. Previously cited in issue 21, p. 3253, Accession no. A89-47690.
Copyright

A91-18911#
ACCURATE METHOD FOR CALCULATING INITIAL DEVELOPMENT OF VORTEX SHEETS
RAJENDRA K. BERA (National Aeronautical Laboratory, Bangalore, India) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 910-912. refs
Copyright

The fast and accurate method presented for obtaining the early evolutionary stages of an initially planar, finite-span vortex sheet can be used to determine wing downwash behind a wing, in such regions as the vicinity of the tail plane. The solution is expressed as a power series in time whose coefficients are calculated via proper numerical evaluation of the accompanying Cauchy integrals. The method does not discretize the vortex sheet. O.C.

A91-19022#
LATERAL STABILITY OF GLIDING PARACHUTES
PETER CRIMI (Textron Defense Systems, Wilmington, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1060-1063. refs
Copyright

The lateral stability of a gliding parachute or other lifting surface with a suspended payload is analyzed to determine the relationship of aerodynamic and inertial parameters to stability characteristics. The system is represented by a rigid wing with a suspended payload in a steady glide. As with conventional fixed-wing aircraft, the lateral response is characterized by an oscillatory response mode and a spiral divergence. The stability boundary for spiral divergence can be prescribed analytically. Calculations show that there is a minimum effective anhedral angle required for absolute stability. Increasing suspension line length is stabilizing for spiral divergence, whereas increasing the glide slope is stabilizing for both spiral divergence and oscillatory response. Author

A91-19102#
AN ANALYSIS OF THE ONSET OF DYNAMIC STALL
JEFFREY CURRIER (McDonnell Douglas Helicopter Co., Mesa, AZ) and K.-Y. FUNG (Arizona, University, Tucson) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by the National Cheng Kung University

and University of Arizona. refs
(Contract AF-AFOSR-88-0163)
(AIAA PAPER 91-0003) Copyright

An investigation of the dynamic stall characteristics of several airfoils in sinusoidal pitch oscillations as well as in constant rate pitch ramps over a wide range of unsteady flow conditions is presented. It is shown that the flow before the onset of stall can be considered quasi-steady predictable employing inviscid theory, and that the effect of unsteadiness on the onset of dynamic stall depends on the airfoil geometry and whether the flow has become locally supersonic, while the effect of the free stream Mach number on the onset is somewhat insensitive to the airfoil geometry. Also, it is found that the dynamic stall onset delay time from the static stall angle decreases with increased unsteadiness, which suggests that separation is being promoted rather than delayed; and that the benefit of dynamic stall is simply taking advantage of the high lift while the separation process lasts. R.E.P.

A91-19106*# Vigyan Research Associates, Inc., Hampton, VA.
TIME-MARCHING METHODS FOR THREE-DIMENSIONAL STEADY AND UNSTEADY VISCOUS IMCOMPRESSIBLE FLOWS
C.-H. HSU (Vigyan, Inc., Hampton, VA), Y.-M. CHEN, and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract NAS1-18585)
(AIAA PAPER 91-0024)

An implicit algorithm for the solution of three-dimensional, steady and unsteady, viscous, incompressible flows is presented. The algorithm is based on an upwind-relaxation finite-difference method. Steady-state solutions are carried out using a time-marching solution technique in combination with a local time-stepping strategy. To obtain time-accurate solutions, a subiterative procedure is employed at each physical time step using a global time step to ensure the divergence-free condition. Steady-state flows in several straight ducts and in a square duct with a 90-degree bend are computed and compared with analytical and experimental results. The classical problem of starting flow in a circular pipe is chosen to verify the time accuracy of the present scheme. Finally, the three-dimensional bubble-type vortex breakdown of a slender cylindrical vortex in an unbounded flow is investigated. Author

A91-19124*# Pennsylvania State Univ., University Park.
A MULTI-POINT INVERSE AIRFOIL DESIGN METHOD BASED ON CONFORMAL MAPPING
MICHAEL S. SELIG and MARK D. MAUGHMER (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(Contract NGT-50341)
(AIAA PAPER 91-0069) Copyright

An exact method of multipoint inverse airfoil design for incompressible flow is presented. Multipoint design is handled by dividing the airfoil into a number of desired segments. For each segment the velocity distribution is prescribed together with an angle of attack at which the prescribed velocity distribution is to be achieved. In this manner, multipoint design objectives can be taken into account in the initial specification of the velocity distribution. In order for the multipoint inverse airfoil design problem to be well posed, three integral constraints and several conditions arise which must be satisfied. Further restrictions are imposed if the airfoil is to have a specified pitching moment, thickness ratio, or other constraints. The system of equations is solved partly as a linear system and partly through multidimensional Newton iteration. Since the velocity distribution is prescribed about the circle in the angular coordinate, specification of the velocity in terms of arc length is handled through the multidimensional Newton iteration as well. The current formulation sets the stage for a more general multipoint inverse airfoil design method in which it will be possible to specify the velocity distribution, some boundary-layer development, or the surface geometry along a segment. Author

A91-19136*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A FAST UPWIND SOLVER FOR THE EULER EQUATIONS ON THREE-DIMENSIONAL UNSTRUCTURED MESHES
NEAL T. FRINK (NASA, Langley Research Center, Hampton, VA), PARESH PARIKH, and SHAHYAR PIRZADEH (Vigyan, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. refs
(AIAA PAPER 91-0102) Copyright

An upwind scheme is presented for solving the three-dimensional Euler equations on unstructured tetrahedral meshes. Spatial discretization is accomplished by a cell-centered finite-volume formulation using flux-difference splitting. Higher-order differences are formed by a novel cell reconstruction process which results in computational times per cell comparable to those of structured codes. The approach yields highly resolved solutions in regions of smooth flow while avoiding oscillations across shocks without explicit limiting. Solutions are advanced in time by a 3-stage Runge-Kutta time-stepping scheme with convergence accelerated to steady state by local time stepping and implicit residual smoothing. Solutions are presented for a range of configurations in the transonic speed regime to demonstrate code accuracy, speed, and robustness. The results include an assessment of grid sensitivity and convergence acceleration by mesh sequencing. Author

A91-19150#
NUMERICAL INVESTIGATION OF SUPERSONIC INLET WITH REALISTIC BLEED AND BYPASS SYSTEMS
AKIRA FUJIMOTO (Kawasaki Heavy Industries, Ltd., Gifu Technical Institute, Kakamigahara, Japan), NOBUO NIWA (Kawasaki Heavy Industries, Ltd., Seishin, Japan), and KEISUKE SAWADA (Tohoku University, Sendai, Japan) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0127) Copyright

A supersonic mixed-compression inlet was designed for Mach 2.5 and aerodynamically analyzed using CFD approach. Its ramp bleed and throat bypass systems were simulated in order to examine the physical nature of a flow around the systems. From the calculation, two types of 'unstart' were predicted. One is a shock/boundary-layer interaction induced 'unstart'. The other is usual 'unstart' due to failure of pressure balance. The boundary-layer control bleed was found to play an important role for avoiding the former 'unstart'. For avoiding or delaying the latter 'unstart', a throat bypass system plays an important role. The shock capturing and stabilizing effect by the throat bypass was also confirmed numerically. Furthermore, the mechanism of improving pressure recovery ahead of an inlet 'unstrat' was examined in detail. As a result, the role of a throat gap, or a slot, was revealed quantitatively for the first time. A streamline passing over the gap automatically constructs an optimum equivalent wall boundary in accordance with the flow conditions around the system. This noteworthy result could be obtained by the great advantage of the CFD approach. Author

A91-19151#
NUMERICAL SIMULATION OF A SUPERSONIC INLET
DONALD P. RIZZETTA (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0128) Copyright

The steady flowfield about a supersonic inlet configuration at a freestream Mach number of 3.5 and unit Reynolds number of 75,600/m was simulated numerically by integration of the time-dependent compressible three-dimensional mass-averaged Navier-Stokes equations. Calculations with and without wall surface bleed on both fine and coarse computational meshes were performed. Effects of fine-scale turbulence were represented by means of a simple algebraic closure model which was formulated to account for multiple intersecting planar walls, adverse pressure gradients, and surface mass transfer. For the case with bleed, twenty discrete porous wall bleed regions were modeled. Results of these computations are analyzed in order to indicate resolution

requirements and the effect of bleed upon the solution. Comparison is made with a previous numerical calculation and with experimental data in terms of static pressure distributions and pitot pressure surveys. Differences in mass flow, pressure recovery, and drag losses between the solutions with and without bleed are examined. Author

A91-19152#
FNS ANALYSIS OF A 3-D SCRAMJET INLET
YEU-CHUAN HSIA, ENDWELL O. DASO, and VIDYA A. PADHYE (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(AIAA PAPER 91-0129) Copyright

Three-dimensional FNS computations have been made on a sidewall compression scramjet inlet at a nominal Mach number of 5. A computer code named USA which solves the full Navier-Stokes equations based on a finite volume approach and a high accuracy TVD scheme was used. The objectives were to establish 3-D scramjet inlet CFD capability, to study the flow structure, and to evaluate the applicability of FNS solutions for inlet performance calculations. Two solutions, one laminar and the other turbulent, were obtained. Inlet performance parameters in terms of air capture ratio, total pressure recovery, and kinetic energy efficiency were calculated using three different averaging methods. Results are compared with the test data reported in 1966. The turbulent solution shows a better agreement with test data than the laminar solution. Author

A91-19166#
SENSITIVITY ANALYSIS APPLIED TO THE EULER EQUATIONS - A FEASIBILITY STUDY WITH EMPHASIS ON VARIATION OF GEOMETRIC SHAPE
ARTHUR C. TAYLOR, III, VAMSHI MOHAN KORIVI, and GENE W. HOU (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 23 p. refs
(Contract NSF DMC-86-57917)
(AIAA PAPER 91-0173) Copyright

An approximation method is presented for efficiently predicting the changes which occur in a steady-state numerical solution of the Euler equations as a consequence of a small change in the geometric shape of the domain. Using a Taylor's series expansion about a known steady-state solution for one geometric shape, the neighboring steady-state solutions for similar geometric shapes are estimated. The technique is implemented using an upwind cell-centered finite volume formulation. The method is successfully applied to two test problems, including a subsonic nozzle (free stream Mach number equals 0.85), and a supersonic inlet (free stream Mach number equals 2.0). In each of these two tests cases, conventional numerical solutions are first obtained for flow through three slightly different geometric shapes. After defining one of these three solutions to be the 'known' solution, the approximation method is used to generate predicted solutions for the remaining two shapes. In both test cases, and for all geometric shape variations which are tested, the predicted solutions compare very well with the conventional numerical solutions, and are computationally less expensive to obtain. Author

A91-19168#
ANALYSIS OF STORE TRAJECTORIES FROM TACTICAL FIGHTER AIRCRAFT
T. L. DONEGAN and J. H. FOX (Calspan Corp.; USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research sponsored by USAF. refs
(AIAA PAPER 91-0183) Copyright

Results are presented from a study of the use of the Euler equations to model complex transonic configurations and to predict store loads. Among the most important issues is the degree of complexity that can be readily accommodated by the methodology while producing accurate store trajectories as well as the effect of geometric simplification on the trajectory of a store. Trajectories for three aircraft configurations at a free stream Mach number of 0.98 and aircraft angle of attack of 1.1 deg are computed based on Euler solutions. Trajectories were compared to both measured online trajectories and computed trajectories based on measured flow fields and measured store carriage loads for verification. It is concluded that some aircraft geometric details may play a more important role than anticipated in computationally determining store trajectories and also that it is possible to use computed store loads and computed flow-field information as an aid in producing trajectories from highly complex aircraft configurations. L.K.S.

A91-19169*# Analytical Methods, Inc., Redmond, WA.
MACH NUMBER VALIDATION OF A NEW ZONAL CFD METHOD (ZAP2D) FOR AIRFOIL SIMULATIONS
DANIEL J. STRASH, MICHAEL SUMMA, and SUNGYUL YOO (Analytical Methods, Inc., Redmond, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract NAS2-12961; NAS2-13194)
(AIAA PAPER 91-0185) Copyright

A closed-loop overlapped velocity coupling procedure has been utilized to combine a two-dimensional potential-flow panel code and a Navier-Stokes code. The fully coupled two-zone code (ZAP2D) has been used to compute the flow past a NACA 0012 airfoil at Mach numbers ranging from 0.3 to 0.84 near the two-dimensional airfoil C(lmax) point for a Reynolds number of 3 million. For these cases, the grid domain size can be reduced to 3 chord lengths with less than 3-percent loss in accuracy for freestream Mach numbers through 0.8. Earlier validation work with ZAP2D has demonstrated a reduction in the required Navier-Stokes computation time by a factor of 4 for subsonic Mach numbers. For this more challenging condition of high lift and Mach number, the saving in CPU time is reduced to a factor of 2. Author

A91-19171*# Rockwell International Corp., Los Angeles, CA.
CFD VALIDATION OF A SUPERSONIC LAMINAR FLOW CONTROL CONCEPT
CHUNG-JIN WOAN, PHILIP B. GINGRICH, and MICHAEL W. GEORGE (Rockwell International Corp., Los Angeles, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by Rockwell International Independent Research and Development Program and NASA. refs
(AIAA PAPER 91-0188) Copyright

A three-dimensional Navier-Stokes code is used in conjunction with a linear compressible stability analysis code to develop a numerical procedure for prediction of laminar flow transition. The procedure is applied to a modified F-16XL fighter with a laminar flow control glove at supersonic speed. Details of boundary layer stability analysis indicate that, computationally, laminar flow could be realized on the highly swept wing in the absence of the leading edge attachment-line contamination. Effects of the three-dimensionality of the flow were shown to be important in the boundary layer stability analysis. The numerically predicted surface pressures compare favorably with the flight test data. Author

A91-19181*# Naval Air Development Center, Warminster, PA.
TRANAIR APPLICATIONS TO TRANSONIC FLOWFIELD PREDICTIONS
A. CENKO, W. TSENG (U.S. Navy, Naval Air Development Center, Warminster, PA), K. PHILLIPS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Carderock, MD), and M. MADSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0201)

Reliable methods for predicting external aircraft flowfields are required for airframe/engine and aircraft/store integrations, as well as for predicting store trajectories. Although Euler methods have demonstrated an impressive capability for predicting aircraft flowfields at all speed regimes, the need to generate a separate grid for any new or modified configuration make these methods impractical to use in a preliminary design environment. The PAN AIR and Nielsen programs are considerably easier to use, but are limited to the linear speed regime. The TranAir program uses

PAN AIR type geometry inputs and works well in the transonic speed regime. It might be the technique of choice for predicting transonic aircraft flowfields. A study was made of the relative merits of Nielsen, PAN AIR and TranAir for predicting the transonic flowfield about the F-18 aircraft. Author

A91-19189*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TURBULENCE MODELING IN AERODYNAMIC SHEAR FLOWS - STATUS AND PROBLEMS
D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 31 p. refs
(AIAA PAPER 91-0214) Copyright

This paper briefly summarizes the status and problems of turbulence modeling for aerodynamical applications. For complex flows the 'approach of choice' is (increasingly) full second-order (Reynolds stress equation) closure. These closures have not yet developed to anywhere near their full potential, significant further research is required especially regarding length-scale equations, representation of pressure-strain correlations, and wall region treatments. Recent developments in computer capability, algorithms, numerical simulations, theory and quantitative flow visualization should assist in and hasten this research. Several problem areas such as shock interaction and discrete dynamic instabilities of turbulent flows may require mega-to-large eddy simulation or theoretical adjuncts. Author

A91-19190*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SECOND-ORDER CLOSURE MODELS FOR SUPERSONIC TURBULENT FLOWS
CHARLES G. SPEZIALE and SUTANU SARKAR (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NAS1-18605)
(AIAA PAPER 91-0217)

Recent work by the authors on the development of a second-order closure model for high-speed compressible flows is reviewed. This turbulence closure is based on the solution of modeled transport equations for the Favre-averaged Reynolds stress tensor and the solenoidal part of the turbulent dissipation rate. A new model for the compressible dissipation is used along with traditional gradient transport models for the Reynolds heat flux and mass flux terms. Consistent with simple asymptotic analyses, the deviatoric part of the remaining higher-order correlations in the Reynolds stress transport equation are modeled by a variable density extension of the newest incompressible models. The resulting second-order closure model is tested in a variety of compressible turbulent flows which include the decay of isotropic turbulence, homogeneous shear flow, the supersonic mixing layer, and the supersonic flat-plate turbulent boundary layer. Comparisons between the model predictions and the results of physical and numerical experiments are quite encouraging. Author

A91-19194*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMMENTS ON REYNOLDS NUMBER EFFECTS IN WALL-BOUNDED SHEAR LAYERS
PROMODE R. BANDYOPADHYAY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(Contract NAS1-18599)
(AIAA PAPER 91-0231) Copyright

The effect of Reynolds number on the structure of turbulent boundary layers and channel flows is discussed. Published data are reexamined in light of the following questions: (1) does the boundary layer turbulence structure change after the well known Reynolds number limit viz, when Re(theta) is greater than 6000?; (2) is it possible to disturb a high Reynolds number flat plate turbulent boundary layer near the wall such that the recovery length is O(100 delta)?; and (3) how close is the numerically simulated low Reynolds number flat plate turbulence structure to that observed experimentally? The turbulence structure appears to change continuously with Reynolds number virtually throughout the bounday layer and sometimes in unexpected manners at high Reynolds numbers. Author

A91-19195*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A GRID-INDEPENDENT APPROXIMATE RIEMANN SOLVER WITH APPLICATIONS TO THE EULER AND NAVIER-STOKES EQUATIONS
CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA), BRAM VAN LEER, and PHILIP L. ROE (Michigan, University, Ann Arbor) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0239) Copyright

A new two-dimensional approximate Riemann solver has been developed that obtains fluxes on grid faces via wave decomposition. By utilizing information propagation in the velocity-difference directions rather than in the grid-normal directions, this flux function more appropriately interprets and hence more sharply resolves shock and shear waves when they lie oblique to the grid. The model uses five waves to describe the difference in states at a grid face. Two acoustic waves, one shear wave, and one entropy wave propagate in the direction defined by the local velocity difference vector, while the fifth wave is a shear wave that propagates at a right angle to the other four. Test cases presented include a shock reflecting off a wall, a pure shear wave, supersonic flow over an airfoil, and viscous separated airfoil flow. Results using the new model give significantly sharper shock and shear contours than a grid-aligned solver. Navier-Stokes computations over an aifoil show reduced pressure distortions in the separated region as a result of the grid-independent upwinding. Author

A91-19197#
ASSESSMENT OF FLUX VECTOR SPLITTING FOR VISCOUS COMPRESSIBLE FLOWS
JAAP J. W. VAN DER VEGT (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0243) Copyright

A fully implicit method for solving the compressible Navier-Stokes equations for flows with both strong shocks and significant viscous effects is described. Special attention is paid to improved flux vector splitting, which minimizes numerical dissipation in boundary layers. The incorporation of viscous effects implicitly and alternatives for solving the resulting very large system are discussed. Results are presented for laminar supersonic flow over a flat plate with adiabatic and isothermal walls at various Mach numbers. Author

A91-19198#
EXPERIMENTAL INVESTIGATION OF LARGE SCALE STRUCTURES IN COMPRESSIBLE MIXING LAYERS
N. L. MESSERSMITH, J. C. DUTTON, and H. KRIER (Illinois, University, Urbana) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. Research supported by the U.S. Navy and USAF. refs
(AIAA PAPER 91-0244) Copyright

The large-scale structures of compressible mixing layers are studied using planar imaging and the statistical analysis of two-dimensional covariance fields. Ensembles of digital images are collected at three different flow conditions with relative Mach numbers of 0.63, 1.24, and 1.49 respectively. For each flow condition, two types of imaging views are considered, transverse and oblique, and for each of these, two different ethanol seeding schemes are employed. The level of three-dimensionality in a compressible mixing layer is found to be a function of relative Mach number. Different characteristics between the transverse and oblique realizations of the scalar transport structures suggests the presence of an organized large-scale mixing layer structure. The current data cannot determine the spanwise extent of these

structures, which is necessary to describe their organization completely. V.T.

A91-19201*# Maryland Univ., College Park.
SHOCK STRENGTH EFFECTS ON SEPARATED FLOWS IN NON-EQUILIBRIUM CHEMICALLY REACTING AIR - SHOCK WAVE/BOUNDARY LAYER INTERACTION
CHARLES A. BALLARO and JOHN D. ANDERSON, JR. (Maryland, University, College Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract AF-AFOSR-88-0101; NAG2-529)
(AIAA PAPER 91-0250) Copyright

This work is part of a general study to examine the effects of nonequilibrium chemical reactions on hypersonic separated flows. In particular, the work presented is the first attempt to quantitatively predict the effects of impinging shock strength on the separation region in non-equilibrium chemically reacting air over a flat plate. Of special interest is the local heat transfer rate to the plate at the reattachment point. The effects of chemically non-equilibrium on the flow field are assessed by making direct comparisons to the results calculated assuming a calorically perfect flow. Chemical reactions are found to increase heat transfer rates, and this increase becomes significantly larger as Reynolds number increases. Author

A91-19202#
EFFECTS OF A STRAKE ON THE FLOW PAST A WING-BODY JUNCTION
WILLIAM J. DEVENPORT, ROGER L. SIMPSON, MICHAEL B. DEWITZ, and NAVAL K. AGARWAL (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract N00014-88-C-0291)
(AIAA PAPER 91-0252) Copyright

Pressure and velocity measurements and oil-flow visualizations are presented to demonstrate the effects of a strake on the flow of a turbulent boundary layer past an idealized wing-body junction. The strake, a large fairing in the corner between the wing nose and body surface, modifies the flow in a way that is desirable in many applications. With the wing at zero angle of attack it eliminates leading-edge separation and thus the formation of a horseshoe vortex around the wing nose. At non-zero angle of attack it is less effective, leading-edge separation occurring on the pressure side of the strake. However, the strake still eliminates much of the unsteadiness and flow non-uniformity associated with the horseshoe vortex. Author

A91-19211#
QUANTITATIVE VISUALIZATION OF JUNCTION AND TIP VORTICES USING PARTICLE DISPLACEMENT VELOCIMETRY
A. SHEKARRIZ, T. C. FU, J. KATZ (Johns Hopkins University, Baltimore, MD), H. L. LIU, and T. T. HUANG (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. Research supported by the U.S. Navy and DARPA. refs
(AIAA PAPER 91-0269) Copyright

This paper describes a series of experiments focussing on development of junction and tip vortices trailing behind a sail attached to a typical underwater body. These experiments were performed in a towing tank and involved implementation of particle displacement velocimetry. The junction vortex was studied at zero incidence whereas the tip vortex was visualized at a side slip angle of 5 deg. The Reynolds number based on the sail chord length was 72,000. A map of the velocity at several streamwise locations was obtained and the circulation was computed. The results reveal a reduction in the circulation of the junction vortex with increasing distance from the sail. Measurement of the circulation of a typical wake vortex at zero incidence reveals that it is comparable in strength to the junction vortex. This result suggests that one cannot ignore the impact of the wake of the sail on the overall flow structures between the junction vortices. Author

A91-19212#
SIMULTANEOUS VELOCITY MAPPING OF FLOW PERTURBATIONS FROM COUNTER ROTATING PROPELLERS
M. C. WILLIAMS and R. D. HOUSE (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p.
(AIAA PAPER 91-0270) Copyright

The paper addresses an investigation of an advanced-design counterrotating propfan, in which the flow perturbations induced by propellers are mapped simultaneously by employing a laser Doppler velocimeter (LDV). A two-color two-component confocal backscatter LDV is utilized. The test plan calls for obtaining radial traverses from the hub region to approximately 10-pct span beyond the rotor tips upstream of the first rotor, between the first and second rotors and downstream of the second rotor plus an axial traverse consisting of 18 points. Modifications implemented during the test program, related to seeding, laser alignment, test section fogging, hub flare, blade geometry, and flow anomalies are covered. Representative data sets showing the velocity perturbations resulting from each of the two independently rotating propellers are analyzed. V.T.

A91-19214#
SYMMETRIC AND ASYMMETRIC VORTEX FLOWS AT HIGH ANGLE OF ATTACK
M. V. LOWSON and A. J. C. PONTON (Bristol, University, England) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0276) Copyright

Theoretical and experimental results for the appearance of asymmetric flows on conical bodies varying from circular cones to delta wings are reported. The appearance of asymmetry in the flow is found to be well predicted by theory for circular cones, and the predicted trend to greater symmetry for thinner bodies is also supported, although not to the extent predicted. The effects of vortex breakdown on the thinner bodies are found to be significant. Data is presented on the development of conical asymmetric, and non-conical flows with free vortices on conical bodies, including the effects of vortex breakdown. The tests cover a range of Re from 20,000 to 3,000,000, with most results at Re = 300,000. No asymmetry is found on thin slender wings. Previously reported asymmetries are shown to be due to the thickness of the apex of the delta wings tested. Author

A91-19215#
UNSTEADY VORTEX FLOW MEASUREMENTS OVER TWIN-TAILED AIRCRAFT AT HIGH ANGLES OF ATTACK
N. M. KOMERATH, R. J. SCHWARTZ, J. M. KIM (Georgia Institute of Technology, Atlanta), and S. PERCIVAL AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by USAF. refs
(AIAA PAPER 91-0279) Copyright

The nature and scaling of narrow-band velocity fluctuations exhibited in the flowfield near the vertical tails of scale models of F-15 and F/A-18 aircraft are studied at high angles of attack using hot-film anemometry. One of the purposes of the study is to determine whether the presence of the tails themselves serves as a source for feedback of pressure pulsations which lead to the organization of vortex flow fluctuations into periodic phenomena. It is concluded that the spectra over the wing show the development of a narrow-band peak and that a dominant spectral peak occurs inboard and outboard of the top of the vertical tails, as well as upstream of the tail leading edge. These and other phenomena observed are found to be similar to those responsible for periodicity in two-dimensional airfoil wakes at high angles of attack, however, they do not obey the same scaling laws. V.T.

A91-19216#
A WATER TUNNEL INVESTIGATION OF THE EFFECTS OF PITCH RATE AND YAW ON LEX GENERATED VORTICES OF AN F/A-18 FIGHTER AIRCRAFT MODEL
SHESHAGIRI K. HEBBAR, MAX F. PLATZER (U.S. Naval Postgraduate School, Monterey, CA), and ODILON V. CAVAZOS

(U.S. Navy, Naval Air Station, San Diego, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research sponsored by the U.S. Navy. refs
(AIAA PAPER 91-0280)

A water tunnel flow visualization investigation was performed into the effects of pitch rate on the development and bursting of vortices generated from the leading edge extensions of a two-percent scale model of an F/A-18 fighter aircraft. The study focussed on simple pitching maneuvers in the angle of attack range 0-50 degrees with yaw angles of 0, 5, 10 and 20 degrees. Results of the dynamic flow visualization study highlight the phenomenon of vortex burst lag associated with pitching motions. For the same pitch rate, vortex bursting was found to occur earlier for the pitch-down motion than for the pitch-up motion, implying aerodynamic hysteresis effects. Yaw effects were more pronounced at low angles of attack. Yawing the model generated significant vortex asymmetries due to the delayed vortex breakdown on the leeward side for yaw angles of less than 10 degrees. Author

A91-19222#
THE EFFECT OF PARTICLE DYNAMICS ON LV MEASUREMENT BIAS IN COMPRESSIBLE, VORTICAL FLOWS
MARK S. MAURICE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0292)

The study deals with the particle dynamics of a seed material model in laser velocimetry (LV) measurements. A three-dimensional potential vortex flowfield is developed and bounded for use as a mathematical model. Curves are presented which can be used to aid in the design and analysis of LV measurements in vortical flows over a large practical range of interest. The particle equations of motion are coupled with a CFD-derived flowfield showing the capability to track the position and velocity bias of LV seed through complex flows numerically. It is shown that the velocity bias within a delta-wing vortex increases rapidly with particle diameter; consequently, particle size should be controlled in order to minimize particle-dynamics basis. V.T.

A91-19235#
RECENT STUDIES ON TRANSITION AND TURBULENCE AT ONERA/CERT
J. COUSTEIX, D. ARNAL, B. AUPOIX, and C. GLEYZES (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(AIAA PAPER 91-0332) Copyright

This paper gives a few examples of the effort which is being done at ONERA/CERT on two subjects: laminar-turbulent transition and turbulence study. One of the main objectives of the investigations on transition is to define tools usable to design an aircraft with laminar wings. Another objective is to determine the effect of roughness with a particular application to the Hermes Project. The studies on turbulence are illustrated with the problem of turbulence models in compressible flow and with a European collaborative effort on three-dimensional turbulent boundary layers and wakes. Author

A91-19237#
DIRECT AND LARGE-EDDY SIMULATIONS OF TRANSITIONING AND TURBULENT SHEAR FLOWS
M. LESIEUR, P. COMTE, and X. NORMAND (Grenoble, Institut de Mecanique, France) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by CNES and CNRS. refs
(Contract DRET-88-150)
(AIAA PAPER 91-0335) Copyright

Natural and controlled transitions in shear flows including a periodic incompressible mixing layer and a compressible boundary layer developing on an insulated flat plate are investigated at M = 0.5 and M = 5. Three-dimensional direct numerical simulations demonstrate that the periodic mixing layer can be subject to a violent three-dimensional instability leading to a vortex-lattice structure if the initial perturbation is random and three-dimensionally isotropic; in the natural-transition experiment, this instability is more amplified than a two-dimensional pairing, while calculations for the controlled-transition experiment show a two-dimensional pairing of large billows with thinner longitudinal vortices stretched in the direction of the basic shear. V.T.

A91-19240*# California Univ., Davis.
DRAG CALCULATIONS OF WINGS USING EULER METHODS
C. P. VAN DAM (California, University, Davis), I. C. CHANG (NASA, Ames Research Center, Moffett Field, CA), P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), and KOOROSH NIKFETRAT AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NCA2-387; NAS1-18240)
(AIAA PAPER 91-0338) Copyright

Several techniques for the calculation of drag using Euler-equation formulations are discussed and compared. Surface-pressure integration (a nearfield technique) as well as two different farfield calculation techniques are described and applied to three-dimensional flow-field solutions for an aspect-ratio-7 wing with attached flow. The present calculations are limited to steady, low-Mach-number flows around three-dimensional configurations in the absence of active systems such as surface blowing/suction and propulsion. Although the main focus of the paper is the calculation of aerodynamic drag, the calculation of aerodynamic lift is also briefly discussed. Three Euler methods are used to obtain the flowfield solutions. The farfield technique based on the evaluation of a wake-integral appears to provide the most consistent and accurate drag predictions. Author

A91-19242#
A COMPARISON BETWEEN TWO THREE-DIMENSIONAL VISCOUS CODES AND EXPERIMENTAL RESULTS FOR HIGH WORK TURBINE
JONG-SHANG LIU, MOHAMED ZEDAN, and RICCARDO BOZZOLA (Textron Lycoming, Stratford, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0341) Copyright

Integration of the three dimensional viscous analysis codes into the turbomachinery engineering design/analysis process has been a major concern of many research institutions and industry in the recent past years. An expensive code validation against experimental data is required before relying on these codes in the turbomachinery design process. Two three-dimensional Navier-Stokes codes are investigated in this paper. The performance of these codes is presented and the turbomachinery flow features are compared with experimental data. A very recently designed transonic high work turbine stator and rotor are used as the test vehicle. The feasibility of using such codes as routine turbomachinery design tools is discussed. Author

A91-19277#
DEVELOPMENT OF AN EFFICIENT INVERSE METHOD FOR SUPERSONIC AND HYPERSONIC BODY DESIGN
W. H. MASON (Virginia Polytechnic Institute and State University, Blacksburg) and JAEWOO LEE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0395) Copyright

An efficient inverse method for supersonic and hypersonic axisymmetric body design is developed for the Euler equations. Numerous surface pressure-body geometry rules are examined to obtain an inverse procedure which is robust, yet demonstrates fast convergence. Each rule is analyzed and examined numerically within the inverse calculation routine for supersonic (M = 3) and hypersonic (M = 6.28) speeds. Based on the analysis, a new method to obtain rapid, reliable convergence is presented. Example results are given for several demanding cases: a hypersonic minimum drag body, a body with an expansion corner, and several bodies derived from specification of extreme target pressure distributions. The new method requires slightly more than twice the CPU time of a direct calculation. Author

A91-19297#
TIME-DEPENDENT POST-STALL AIRFOIL BEHAVIOR IN A PERIODIC WAKE FLOW
DAVID J. GWILLIAM, JR. and RICHARD M. HOWARD (U.S. Naval Postgraduate School, Monterey, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 91-0431)

The time-dependent response of poststall flow over an airfoil subjected to a periodic turbulent-wake flow convected in the freestream was characterized by phase-locked ensemble-average streamwise velocity profiles measured at 70 percent chord at 22 deg angle of attack. The flow was found to stabilize and reattach for part of the periodic cycle, somewhat analogous to the effects of dynamic stall. The stabilizing mechanism differed from that determined to stabilize a turbulent boundary layer for attached flows in previous tests. Reduced frequencies of the input compared to those found advantageous in dynamic-stall studies, these frequencies are an order of magnitude less than those found to successfully stabilize a turbulent boundary layer in the previous work. Of interest will be how this phenomenon might be used for control at high angles of attack for enhanced maneuvering.
Author

A91-19298#
UNSTEADY CIRCULATION CONTROL AERODYNAMICS OF A CIRCULAR CYLINDER WITH PERIODIC JET BLOWING
TERENCE A. GHEE and J. GORDON LEISHMAN (Maryland, University, College Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. Research supported by the Minta-Martin Aeronautical Fund. refs
(AIAA PAPER 91-0433) Copyright

An experimental investigation was conducted into the unsteady circulation control aerodynamnics of a circular cylinder with periodic blowing from a wall jet. Both steady and unsteady surface pressure data were obtained for a variety of slot angles, blowing frequencies, and mean blowing coefficients. The experiments were run primarily at a Reynolds number of 190,000 both transition free and transition fixed. Measurements were made of the time-dependent pressures at 30 locations around the cylinder and were numerically integrated to find the unsteady lift and pressure drag on a section at mid-span. Significant hysteresis effects on the air-loads were observed, these effects increasing with increasing blowing frequency. The results showed that the lift augmentation ratio was significantly increased relative to the static lift augmentation by the effects of periodic blowing. The maximum unsteady lift was also greater under unsteady conditions, although the mean lift was, in some cases, less than the static values for corresponding mean blowing levels. Additionally, a frequency dependent jet detachment effect was observed.
Author

A91-19299*# Notre Dame Univ., IN.
UNSTEADY SURFACE PRESSURE MEASUREMENTS ON A SLENDER DELTA WING UNDERGOING LIMIT CYCLE WING ROCK
ANDREW S. ARENA, JR. and ROBERT C. NELSON (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by the University of Notre Dame. refs
(Contract NCA2-406)
(AIAA PAPER 91-0434) Copyright

An experimental investigation of slender wing limit cycle motion known as wing rock was investigated using two unique experimental systems. Dynamic roll moment measurements and visualization data on the leading edge vortices were obtained using a free to roll apparatus that incorporates an airbearing spindle. In addition, both static and unsteady surface pressure data was measured on the top and bottom surfaces of the model. To obtain the unsteady surface pressure data a new computer controller drive system was developed to accurately reproduce the free to roll time history motions. The data from these experiments include, roll angle time histories, vortex trajectory data on the position of the vortices relative to the model's surface, and surface pressure measurements as a function of roll angle when the model is stationary or undergoing a wing rock motion. The roll time history data was numerically differentiated to determine the dynamic roll moment coefficient. An analysis of these data revealed that the primary mechanism for the limit cycle behavior was a time lag in the position of the vortices normal to the wing surface.
Author

A91-19300*# Old Dominion Univ., Norfolk, VA.
UNSTEADY VORTEX-DOMINATED FLOW AROUND WINGS WITH OSCILLATING LEADING-EDGE FLAPS
OSAMA A. KANDIL and AHMED A. SALMAN (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(Contract NAG1-648)
(AIAA PAPER 91-0435) Copyright

Unsteady vortex-dominated flow around delta wings with oscillating leading-edge flaps represents an important classs of problems for supermaneuverability and flow control of advanced aircraft. The problem is solved using time accurate integration of the unsteady, compressible, thin-layer Navier-Stokes equations in conjunction with the unsteady, linearized, Navier-displacement equations. Starting with an initial configuration of the wing and its flaps, the Navier-Stokes equations are solved on an initial structured grid for the steady flow. The forced oscillation of the flaps is then applied, and the problem is solved accurately in time. The Navier-displacement equations are solved for the grid deformation and the Navier-Stokes equations are solved for the flowfield. Symmetric and anti-symmetric flaps oscillations are presented to study the effect of the flaps oscillation on the leading-edge vortical flow.
Author

A91-19315#
DIFFICULTIES ASSOCIATED WITH THE HEAT FLUX COMPUTATIONS OF HIGH SPEED FLOWS BY THE NAVIER-STOKES EQUATIONS
KLAUS A. HOFFMANN (Wichita State University, KS), MOHAMMAD S. SIDDIQUI, and STEVE T. CHIANG (Texas, University, Austin) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0467) Copyright

The paper concentrates on heat-transfer computations for high-speed flows around hypersonic vehicles, with focus placed on the dependency of the computational grid system on the wall flux quantities. A procedure providing appropriate grid systems for accurate heat-transfer computations is developed. In order to avoid the introduction of damping terms into numerical calculations, a flux-vector splitting scheme is employed. The effect of the flow Mach number and Reynolds number is illustrated on a generic blunt cone configuration. A set of guidelines providing the minimum requirement of a grid system is outlined.
V.T.

A91-19343*# Princeton Univ., NJ.
AN EXPLORATORY STUDY OF A THREE-DIMENSIONAL SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTION IN A CORNER
S. M. BOGDONOFF and K. PODDAR (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(Contract AF-AFOSR-89-0033; NAG3-926)
(AIAA PAPER 91-0525) Copyright

Three-dimensional shock wave turbulent boundary layer interactions in a corner have been studied at M about 3. The first phase, detailed mean wall static pressure distributions, has shown the interaction of a two-dimensional flow on one wall with the three-dimensional flow generated by a fin. Major three-dimensional effects on both flows were observed, extending from the interaction of the initial region of the three-dimensional flow and the corner. A large part of the resulting corner flow has little resemblance to either the two-dimensional or three-dimensional interacting flows.
Author

A91-19345*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NONADIABATIC AND THREE-DIMENSIONAL EFFECTS IN COMPRESSIBLE TURBULENT BOUNDARY LAYERS
RICHARD W. BARNWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0528) Copyright

A defect stream function formulation for nonadiabatic flow with small crossflow is developed. The first-integral property of this formulation provides for two removal of the streamline curvature term in the governing equation so that the form of the reduced equation for small crossflow is the same as that for two dimensional flow. The combined law of the wall and wake is used in place of the no-slip boundary condition. The tangential velocity equation for law-of-the-wall flow is shown to be the same for three-dimensions as for two when the Boussinesq approximation applies, and a closed form solution for the crossflow angle in the inner region is obtained. Analytic solutions for nonadiabatic, compressible, equilibrium flow with a Clauser outer-region eddy-viscosity model are obtained, and excellent agreement with experimental skin friction and velocity profile data for nonadiabatic, compressible flat-plate flow is achieved. An analytic solution for a linear inner-region eddy-viscosity model is also obtained; the wake function part of this solution is found to be inconsistent with the empirically established law of the wake. Author

A91-19355*# Old Dominion Univ., Norfolk, VA.
THIN-LAYER AND FULL NAVIER-STOKES, LOCALLY-CONICAL AND THREE-DIMENSIONAL ASYMMETRIC SOLUTIONS
O. A. KANDIL, T.-C. WONG, H. A. KANDIL (Old Dominion University, Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(Contract NAS1-18584-71; NAG1-994)
(AIAA PAPER 91-0547)

The unsteady, compressible thin-layer and full Navier-Stokes equations are used to numerically simulate steady and unsteady asymmetric, supersonic, locally-conical flows around a 5-deg-semiapex angle circular cone. The main computational scheme used for the present computations is the implicit, upwind, flux-difference splitting, finite-volume scheme. Comparisons of the solutions using the two sets of equations are presented for the flow asymmetry and its control. Computational studies are also presented to investigate the effects of the freestream Reynolds number and the locally-scaled Reynolds number on the flow asymmetry. These studies are carried out using the full Navier-Stokes equations. Three-dimensional, asymmetric flow solutions are also presented for a 5-deg-semiapex angle cone of unit length and a cone-cylinder configuration. The three-dimensional solutions are obtained by using the thin-layer equations and short-duration transient side-slip disturbances along with a very fine grid. Author

A91-19357#
CONSTRUCTING NONLINEAR AERODYNAMIC DATABASES
R. MEYER (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p.
(AIAA PAPER 91-0552) Copyright

A method for processing wind-tunnel data in order to generate a nonlinear aerodynamic database for stability, control, and performance analyses is presented. The method is based on the application of Fourier techniques to the representation of nonlinear wind-tunnel data. Pitching-moment versus angle-of-attack data for various tail settings is used as an example for demonstrating the approach. By using series terms derived from the data itself, the Fourier method adapts to the unique characteristics of the dataset making it possible to construct a nonlinear aerodynamic database model directly from raw wind-tunnel data. V.T.

A91-19377*# North Carolina State Univ., Raleigh.
FLOW INTERACTION AND NOISE FROM A COUNTER ROTATING PROPELLER
JIN-DEOG CHUNG, JAMES L. WALLS, and ROBERT T. NAGEL (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by the McDonnell Douglas Corp. refs
(Contract NAG3-855)
(AIAA PAPER 91-0596) Copyright

The aerodynamic interaction between the forward and rear rotors in a counter rotating propeller (CRP) system, has been examined using a conditional sampling technique applied to three-dimensional thermal anemometer data. The technique effectively freezes the rotors in any desired relative position and provides the inter-rotor flow field. Axial, radial and circumferential mean flow between rotors is shown relative to the 'fixed' forward rotor for various 'fixed' aft rotor positions. Acoustic far field noise data have also been collected for the same operating conditions. The acoustic results are presented with emphasis on the blade passing frequencies and interaction tone of the CRP. Author

A91-19378#
PERIODIC FLOWS ON RIGID AEROFOILS AT TRANSONIC SPEEDS
S. R. MOHAN (Cranfield Institute of Technology, England) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0598) Copyright

An experimental investigation was undertaken to study periodic flows at transonic speeds on five representative airfoil sections to examine the existence of periodic flows and to determine the conditions associated with them. The experiments show that the periodic flow occurs at the beginning of shock-induced separation and over the instability region, the Mach number just ahead of the shock lies in a narrow range 1.22-1.28. The position of the shock wave is an important parameter that determines the frequency of the periodic flow. A method for alleviating the periodic flow on a 14-percent biconvex airfoil is described. Author

A91-19383*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF A NEW K-TAU MODEL TO NEAR WALL TURBULENT FLOWS
R. ABID, C. G. SPEZIALE, and S. THANGAM (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract NAS1-18605)
(AIAA PAPER 91-0614) Copyright

A recently developed K-tau model for near wall turbulent flows is applied to a variety of test cases. The turbulent flows considered include the incompressible flat plate boundary layer with adverse pressure gradients, incompressible flow past a backward facing step, and the supersonic flat plate boundary layer at zero pressure gradient. Calculations are performed for this two-equation model using an anisotropic as well as isotropic eddy-viscosity. The model predictions are shown to compare quite favorably with experimental data. Author

A91-19386*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL USING FOREBODY STRAKES
T. TERRY NG and GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(Contract NAS2-13155)
(AIAA PAPER 91-0618) Copyright

Aerodynamic control using a rotatable, miniature nose-tip strake system was investigated in a water tunnel with a forebody model. Flow visualization and yawing moment measurements were performed. The results show that the system was highly effective in controlling the forebody vortices and producing controlled yawing moments at moderate-to-high angles of attack. In comparison with the forebody strakes used in several previous studies, the system

can potentially be substantially smaller in size, simpler in operation, and effective over wide ranges of angles of attack and sideslip. Author

A91-19387*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL USING FOREBODY BLOWING AND SUCTION
T. TERRY NG and GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(Contract NAS2-13155)
(AIAA PAPER 91-0619) Copyright

Aerodynamic control using pneumatic forebody flow control was studied. Three methods of control were investigated: (1) blowing from a localized jet, (2) blowing from a slot, and (3) surface suction. Flow visualization and yawing moment measurements were performed on F/A-18 models in a water tunnel. The results show that all the methods were effective in controlling the forebody flow over a wide range of angles of attack and sideslip. The advantages and limitations of each of the control methods were discussed. The experiments suggested that all the control methods work basically on the principle of separation control. Based on the results of the water tunnel tests, the blowing or suction mass flow requirements appear to be within the limits of typical engine-bleed available from a modern fighter engine. Author

A91-19393*# Rutgers Univ., New Brunswick, NJ.
THREE-DIMENSIONAL SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTIONS GENERATED BY A SHARP FIN AT MACH 4
DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ), C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA), and GARY S. SETTLES (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(Contract AF-AFOSR-86-0266; AF-AFOSR-89-0315; NAG2-592)
(AIAA PAPER 91-0648) Copyright

This paper describes a combined experimental and theoretical study of three-dimensional swept shock wave-turbulent boundary layer interactions at Mach 4 generated by a sharp fin of angles alpha equals 16 and 20 degrees. The theoretical model is the three-dimensional compressible Reynolds-averaged Navier-Stokes equations with turbulence incorporated through the algebraic eddy viscosity model of Baldwin and Lomax. Previous computations have been performed by Horstman using the Baldwin-Lomax, Cebeci-Smith and Jones Launder models. Computed results for the surface pressure, skin friction and streamline angles are compared with experiment and previous numerical results. The present results display good agreement with experimental data for surface pressure and surface flow direction. All turbulence models fail to accurately predict the peak skin friction. The computed flowfields are in agreement with many of the features of the quasi-conical flowfield model of Settles. Author

A91-19394*# Rutgers Univ., New Brunswick, NJ.
CROSSING SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTIONS
N. NARAYANSWAMI, D. D. KNIGHT (Rutgers University, New Brunswick, NJ), S. M. BOGDONOFF (Princeton University, NJ), and C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 24 p. Research supported by NSF. refs
(Contract AF-AFOSR-86-0266; AF-AFOSR-89-0033)
(AIAA PAPER 91-0649) Copyright

Three-dimensional interactions between crossing shock waves generated by symmetric sharp fins and a turbulent boundary layer on a flat plate are investigated experimentally and theoretically at Mach number 2.95 and freestream unit Reynolds number 1.96 x 10 to the 7th/ft. The incoming boundary layer has a thickness of 4 mm at the location of the fin leading edges. A comparison of experimental and computational results for two sets of fin angles (11 x 11 and 9 x 9 deg) shows general agreement with regard to surface pressure measurements and surface streamline patterns. The principal feature of the streamline structure is a collision of counterrotating vortical structures emanating from near the fin leading edges and meeting at the geometric centerline of the interaction. Author

A91-19395*# North Carolina State Univ., Raleigh.
AN EFFICIENT SOLUTION TECHNIQUE FOR SHOCKWAVE-BOUNDARY LAYER INTERACTIONS WITH FLOW SEPARATION AND SLOT SUCTION EFFECTS
JACK R. EDWARDS and D. SCOTT MCRAE (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. Research supported by USAF and U.S. Navy. refs
(Contract NAGW-1072)
(AIAA PAPER 91-0652) Copyright

An efficient method for computing two-dimensional compressible Navier-Stokes flow fields is presented. The solution algorithm is a fully-implicit approximate factorization technique based on an unsymmetric line Gauss-Seidel splitting of the equation system Jacobian matrix. Convergence characteristics are improved by the addition of acceleration techniques based on Shamanskii's method for nonlinear equations and Broyden's quasi-Newton update. Characteristic-based differencing of the equations is provided by means of Van Leer's flux vector splitting. In this investigation, emphasis is placed on the fast and accurate computation of shock-wave-boundary layer interactions with and without slot suction effects. In the latter context, a set of numerical boundary conditions for simulating the transpiration flow in an open slot is devised. Both laminar and turbulent cases are considered, with turbulent closure provided by a modified Cebeci-Smith algebraic model. Comparisons with computational and experimental data sets are presented for a variety of interactions, and a fully-coupled simulation of a plenum chamber/inlet flowfield with shock interaction and suction is also shown and discussed. Author

A91-19410#
UNSTEADY WIND-TUNNEL INTERFERENCE IN DYNAMIC TESTING
MARTIN E. BEYERS (Institute for Aerospace Research, Ottawa, Canada) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0682) Copyright

An analysis of existing oscillatory and rotary test data was undertaken to identify the origins of the observed large wind-tunnel interference effects and, subsequently, interpret the aircraft aerodynamic characteristics. Logical arguments based on the limited experimental data point to the existence of interference flow mechanisms involving the coupling between unsteady flow fields near the model, the tunnel walls and around the model support. Oscillatory derivatives measured on the Standard Dynamics Model were significantly affected at low angles of attack while an unstable yawing moment characteristic of the HIRM 2 aircraft configuration at high incidence was masked completely in rotary tests performed in a small test section. Both of these very different problems may be attributed to unsteady wind-tunnel interference. Analytical corrections are not feasible at present, but experimental solutions can be implemented. Predictions of vehicle dynamics at high alpha based on dynamic wind tunnel data can be affected by the interpretation given to the prevailing interference flow phenomena. Author

A91-19412#
VISCOUS DRAG REDUCTION ON TRANSPORT AIRCRAFT
J. SZODRUCH (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research supported by BMFT. refs
(AIAA PAPER 91-0685) Copyright

In the very near future environmental aspects will be of growing importance challenging not only engine manufacturers but also the development of airframes. In all respects, the classical field of aerodynamics offers still a large potential for aircraft improvement. Viscous drag accounts for about 50 percent of the

total drag of an aircraft. The present paper describes two possibilities of reducing drag: in a turbulent boundary layer by riblet film and secondly by keeping the boundary layer laminar over a major part of the wing. In both fields, extensive research programs have been carried out, culminating in successful flight tests with transport aircraft. Author

A91-19421*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ENGINEERING CALCULATIONS OF THREE-DIMENSIONAL INVISCID HYPERSONIC FLOW FIELDS
CHRISTOPHER J. RILEY (NASA, Langley Research Center, Hampton, VA) and FRED R. DEJARNETTE (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0701) Copyright

An approximate solution technique has been developed for three-dimensional, inviscid, hypersonic flows. The method uses Maslen's explicit pressure equation and the assumption of approximate stream surfaces in the shock layer. This approximation represents a simplification of Maslen's asymmetric method. The solution procedure involves iteratively changing the shock shape in the subsonic-transonic region until the correct body shape is obtained. Beyond this region, the shock surface is determined by using a marching procedure. Results are presented herein for a paraboloid and elliptic cone at angle of attack. Calculated surface pressure distributions, shock shapes, and property profiles are compared with experimental data and finite-difference solutions of the Euler equations. Comparisons of the results of the present method with experimental data and detailed predictions are very good. Since the present method provides a very rapid computational procedure, it can be used for parametric or preliminary design applications. One useful application would be to incorporate a heating procedure for aerothermal studies. Author

A91-19422*# Georgia Inst. of Tech., Atlanta.
AN EFFICIENT HYBRID SCHEME FOR THE ANALYSIS OF COUNTER ROTATING PROPELLERS
R. SRIVASTAVA and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract NAG3-730)
(AIAA PAPER 91-0703) Copyright

An efficient solution procedure has been developed for analyzing inviscid unsteady flow past counter rotating propellers. This scheme is first order accurate in time and second order in space, and has been extended to fourth order accuracy in the axial direction. The solution procedure has been applied to a 2-bladed SR-7 single rotation propeller and to a GE F7/A7 counter rotation propeller. The pressure coefficients and the global quantities, power and thrust, show good comparison with experimental measurements. Author

A91-19423#
FLOWFIELD OF A SWEPT BLADE TIP AT HIGH PITCH ANGLES
N. M. KOMERATH, S.-G. LIOU, and J.-S. HYUN (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract DAAL03-88-C-0003)
(AIAA PAPER 91-0704) Copyright

Laser sheet flow visualization and laser Doppler velocimetry are used to study the flow around a swept blade tip configuration. These techniques are used under conditions which simulate the high angles of attack encountered on the retreating blade. It was found that the flow separation was minimal at 15 deg pitch for both rotating and fixed-wing conditions. K.K.

A91-19424#
TEMPORALLY AND SPATIALLY RESOLVED FLOWS WITHIN AND AFT OF A SINGLE ROTATION PROP-FAN
R. CHARLES STAUTER (United Technologies Research Center, East Hartford, CT) and DAVID J. PARZYCH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0705) Copyright

The fluid dynamics of advanced Prop-Fan designs are extremely complex, due in part to the complicated blade geometry. It is necessary to acquire fluid dynamic data that capture both the temporal and spatial variations of the flowfield in order to properly understand and model the physics of the flow. The temporal and spatial variations in the velocity field within and downstream of a single rotation Prop-Fan have been investigated with a laser Doppler velocimeter system. Spatial variations were examined by traversing the probe volume radially through a matrix of measurement stations at several axial locations, while temporal resolution was achieved by acquiring all data as a function of the instantaneous rotor position. Hence, the data set reveals temporal and spatial variations in the Prop-Fan flow field. The data clearly show the presence of significant vortical structures within the field, which seem to differ from similar structures observed on swept vanes and delta wings. Author

A91-19425*# Sterling Software, Palo Alto, CA.
A MULTIBLOCK/MULTIGRID EULER ANALYSIS OF A PROPFAN TRANSPORT WITH WING-MOUNTED NACELLES, INCLUDING SLIPSTREAM EFFECTS
BRIAN A. NISHIDA, RONALD G. LANGHI (Sterling Software, Palo Alto, CA), and DANIEL P. BENCZE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(AIAA PAPER 91-0706)

A multiblock/multigrid computation of the inviscid flow over a wing-mounted propfan transport with propwash is presented. An explicit multistage scheme drives the integral Euler equations to a steady state solution, while an actuator disk approximates the slipstream effects of the propfan blades. Practical applications of detailed surface gridding, multiple block field grids and multigrid convergence acceleration are demonstrated. Author

A91-19429*# Nielsen Engineering and Research, Inc., Mountain View, CA.
ESTIMATION OF ADDITIVE FORCES AND MOMENTS FOR SUPERSONIC INLETS
STANLEY C. PERKINS, JR. and MARNIX F. E. DILLENIUS (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by USAF and NASA. refs
(AIAA PAPER 91-0712) Copyright

A technique for estimating the additive forces and moments associated with supersonic, external compression inlets as a function of mass flow ratio has been developed. The technique makes use of a low order supersonic paneling method for calculating minimum additive forces at maximum mass flow conditions. A linear relationship between the minimum additive forces and the maximum values for fully blocked flow is employed to obtain the additive forces at a specified mass flow ratio. The method is applicable to two-dimensional inlets at zero or nonzero angle of attack, and to axisymmetric inlets at zero angle of attack. Comparisons with limited available additive drag data indicate fair to good agreement. Author

A91-19436#
COMPARISON OF 2D UNSTRUCTURED GRID GENERATION TECHNIQUES
GREGORY S. SPRAGLE (General Dynamics Corp., Fort Worth, TX), WILLIAM R. MCGRORY (Walters Software, Inc., Blacksburg, VA), and JIUNN FANG AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 20 p. refs
(AIAA PAPER 91-0726) Copyright

Two-dimensional unstructured grid generation techniques are evaluated based on the criteria of grid quality, efficiency, robustness, maintainability, and ease of extension to three dimensions. The study includes a description of the methods

investigated, including quadtree, advancing front, and Delaunay schemes. Further, grids generated about three configurations, a crew escape capsule, a multi-element airfoil, and a hypersonic aircraft/store configuration are presented and used to evaluate the methods. The Delaunay sweepline method proved to be the most efficient and effective technique based on the present evaluation. Author

A91-19438*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONICAL EULER METHODOLOGY FOR UNSTEADY VORTICAL FLOWS ABOUT ROLLING DELTA WINGS
ELIZABETH M. LEE and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0730) Copyright

A conical Euler methodology was developed to study unsteady vortex-dominated flows about rolling highly swept delta wings undergoing either forced or free-to-roll motions. The flow solver of the code involves a multistage Runge-Kutta time-stepping scheme which uses a finite-volume spatial discretization of the Euler equations on an unstructured grid of triangles. Results are presented for a 75-deg swept sharp-leading-edge delta wing at a freestream Mach number of 1.2 and at alpha = 10, 20, and 30 deg. At the 10 and 20 deg, forced harmonic analyses indicate that the rolling moment coefficients provide a positive damping which is verified by free-to-roll calculations. In contrast, at 30 deg, a forced harmonic analysis indicates that the rolling moment coefficient provides a negative damping at the small roll amplitudes. A free-to-roll calculation for this case produces an initially divergent response, but as the amplitude of motion grows with time, the response transitions to a wing-rock type of limit cycle oscillation. Author

A91-19444# North Carolina State Univ., Raleigh.
USE OF FINITE VOLUME SCHEMES FOR TRANSITION SIMULATION
CHARLES C. FENNO, JR., H. A. HASSAN (North Carolina State University, Raleigh), and CRAIG L. STREETT (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. Research supported by USAF and U.S. Navy. refs
(Contract NCC1-22; NAGW-1022; NAGW-1331)
(AIAA PAPER 91-0743) Copyright

The use of finite-volume methods in the study of spatially and temporally evolving transitional flows over a flat plate is investigated. Schemes are developed with both central and upwind differencing. The compressible Navier-Stokes equations are solved with a Runge-Kutta time stepping scheme. Disturbances are determined using linear theory and superimposed at the inflow boundary. Time accurate integration is then used to allow temporal and spatial disturbance evolution. Characteristic-based boundary conditions are employed. The requirements of using finite-volume algorithms are studied in detail. Special emphasis is placed on difference schemes, grid resolution, and disturbance amplitudes. Moreover, comparisons are made with linear theory for small amplitude disturbances. Both subsonic and supersonic flows are considered, and it is shown that the locations of branch 1 and branch 2 of the neutral stability curve are well predicted, given sufficient resolution. Author

A91-19457*# General Dynamics Corp., Fort Worth, TX.
PROPULSION-INDUCED AERODYNAMICS OF AN EJECTOR-CONFIGURED STOVL FIGHTER AIRCRAFT
WILLIAM A. POPPEN (General Dynamics Corp., Fort Worth, TX), BRIAN E. SMITH (NASA, Ames Research Center, Moffett Field, CA), and J. DAVID LYE (Boeing Canada, de Havilland Div., Toronto) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. refs
(AIAA PAPER 91-0765) Copyright

Propulsion-induced aerodynamic effects are computed by using data obtained from tests of a full-scale model of the E-7A configuration that were run in the NASA Ames 40 x 80 and 80 x 120-foot tunnels. These effects are shown both in aerodynamic coefficients and nondimensionalized by thrust versus equivalent velocity. The test results show that the full-scale ventral nozzle-induced effects are smaller than scale model data, while the ejector-induced effects demonstrate fair agreement. The effect of tunnel test section size is primarily observed at low and static speed, high thrust conditions, as seen in comparisons of data from both tunnels. The 80 x 120-foot tunnel test gave better static thrust calibrations and permitted a greater range of test freestream velocities and angles-of-attack, extending the database provided by the full-scale model. R.E.P.

A91-19458#
EVALUATION OF A FOURTH-ORDER COMPACT OPERATOR SCHEME FOR EULER/NAVIER-STOKES SIMULATIONS OF A ROTOR IN HOVER
MARILYN J. SMITH and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by McDonnell-Douglas Helicopter Independent Research and Development Funds. refs
(AIAA PAPER 91-0766) Copyright

The application of Euler and Navier-Stokes computational methods in practical design use is limited by their excessive computational and memory requirements. A fourth order compact scheme which promises greater accuracy has been incorporated into an implicit finite-difference rotor solver. Additional cost and memory reductions are achieved through smaller grid requirements. Lifting and nonlifting solutions are presented for a rotor in hover. Grid size and dissipation effects are also discussed. This paper represents the first known application of a fourth order compact operator stencil to rotary wing flows. Author

A91-19459#
FLOW VISUALIZATION FOR A STOVL AIRCRAFT IN GROUND PROXIMITY
L. SCOTT MILLER, MICHAEL PAPADAKIS, and STEVE KLAUSMEYER (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by Boeing Co. refs
(AIAA PAPER 91-0769) Copyright

The purpose of the study is to investigate the three-dimensional flow field character of a simple STOVL aircraft configuration in ground proximity using flow-visualization methods. Potential aerodynamic effects on aircraft performance, including suckdown and exhaust ingestion are included in the investigation. Cross-flow intensity, nozzle exit distance from the ground plane, nozzle spacing, jet mass flow rates, and aircraft angle of attack are among principle test variables. Water-tunnel test results indicate body and flow field vortex formations, jet interaction effects, jet unsteadiness, and a horseshoe-shaped ground vortex. In some cases, vortices rotating about an axis normal to the ground plane are observed, and under certain conditions, these vortices touch down before dissipating. The possibility for exhaust reingestion problems at low heights is also confirmed. V.T.

A91-19460#
STABILIZATION OF THE BURNETT EQUATIONS AND APPLICATION TO HIGH-ALTITUDE HYPERSONIC FLOWS
ROBERT W. MACCORMACK, DEAN R. CHAPMAN (Stanford University, CA), and XIAOLIN ZHONG AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 22 p. refs
(Contract DAAL03-86-K-0139; DAAL03-90-G-0031)
(AIAA PAPER 91-0770) Copyright

In order to stabilize the conventional Burnett equations, a set of augmented Burnett equations is developed with the help of the linearized stability analysis. Both one-dimensional shock-wave structures and two-dimensional flows past blunt leading edges are computed using the new equations. The stability of the conventional Burnett equations and the augmented Burnett equations are tested, along with the inverse density thickness of shock waves. It is demonstrated that the augmented Burnett equations are always stable in the theoretical analysis as well as in both the

one-dimensional and two-dimensional numerical computation tests while maintaining the same accuracy as the conventional Burnett equations. At high altitudes, the difference between two-dimensional computational results of the Burnett equations and those of the Navier-Stokes equations is significant, which makes it preferable to use the Burnett equations. V.T.

A91-19461*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF A PARALLEL DSMC METHOD TO HYPERSONIC RAREFIED FLOWS
RICHARD G. WILMOTH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0772) Copyright

This paper describes a method for doing direct simulation Monte Carlo (DSMC) calculations using parallel processing and presents some results of applying the method to several hypersonic, rarefied flow problems. The performance and efficiency of the parallel method are discussed. The applications described are the flow in a channel and the flow about a flat plate at incidence. The results show significant advantages of parallel processing over conventional scalar processing and demonstrate the scalability of the method to large problems. Author

A91-19462*# Vigyan Research Associates, Inc., Hampton, VA.
AEROTHERMODYNAMICS OF A 1.6-M-DIAMETER SPHERE IN HYPERSONIC RAREFIED FLOW
VIRENDRA K. DOGRA (Vigyan Research Associates, Inc., Hampton, VA), RICHARD G. WILMOTH, and JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0773)

Results of a numerical study using the direct simulation Monte Carlo (DSMC) method are presented for hypersonic rarefied flow about a 1.6-m-diameter sphere. The flow conditions considered are those experienced by a typical satellite in orbit or by a space vehicle during entry. The altitude range considered is that from 90 to 200 km, which encompasses the near continuum, transitional and free-molecular flow regimes. A freestream velocity of 7.5 km/s is assumed in the simulations. The results show that transitional effects are significant at all altitudes below 200 km, but at 200 km the flow about the sphere attains the free-molecular limit. Very little chemical activity is present above 120 km. Both the stagnation point heat transfer and the sphere drag approach their respective free molecule values at 200 km. Results highlight the thermal and chemical nonequilibrium nature of the flowfield. Nonequilibrium effects on the surface heating and body drag are also investigated. Author

A91-19585
POSTPROCESSING OF EXPERIMENTAL AND NUMERICAL RESULTS ON TWO- AND THREE-DIMENSIONAL SHEAR FLOW [POST-TRAITEMENT DES RESULTATS EXPERIMENTAUX ET NUMERIQUES DANS LE CAS DES ECOULEMENTS CISAILLES BI ET TRIDIMENSIONNELS]
C. GLEYZES and G. PAILHAS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 32 p. In French. refs
(AAAF PAPER NT 89-25) Copyright

Some of the solutions chosen at CERT-DERAT to represent experimetal and calculation results on two- and three-dimensional shear flows are presented. Particular consideration is given to the determination of local parameters, e.g., pressure, mean velocities, and Reynolds stresses; the calculation of wall streamlines on the basis of studies of boundary layers on three-dimensional bodies and comparison with wall visualization; the determination of global parameters in three-dimensional flow; and the representation of secondary flows in three-dimensional vortex wakes. B.J.

A91-19592
METHODS FOR DETECTING AND MEASURING BOUNDARY LAYER TRANSITION EMPLOYED AT CERT/DERAT [MOYENS DE DETECTION ET DE MESURES DE LA TRANSITION DE LA COUCHE LIMITE UTILISES AU CERT/DERAT]
J. C. JUILLEN and D. ARNAL (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 42 p. In French. refs
(AAAF PAPER NT 89-14) Copyright

Experimental procedures to measure and correct boundary layer transition data are presented. Results are indicated for each of the procedures, along with some examples of applications, including the transition on a sweptback wing in a wind tunnel, transition in supersonic flight, and liquid crystal visualizations. It is shown that, for tests in an industrial wind tunnel or in flight, IR thermography or liquid crystals provide numerous advantages; the use of hot bonded coatings provides more detailed results, such as the possibility of friction measurement. R.E.P.

A91-19593
INTERACTION BETWEEN A VORTEX AND A PROFILE - UNSTEADY WALL PRESSURE MEASUREMENTS [INTERACTION ENTRE UN TOURBILLON ET UN PROFIL - MESURES DE PRESSION PARIETALES INSTATIONNAIRES]
J. PEUBE, B. FERRET, and S. GABARD (Poitiers, Universite, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 27 p. In French. refs
(AAAF PAPER NT 89-13) Copyright

A facility has been implemented to measure unsteady wall pressures with the aim of investigating vortex-profile interaction. A restricter has been introduced to eliminate adverse effects connected with resonant vibrations of the sensor/pneumatic link circuit. Wall-pressure measurements were carried out using a Scanivalve sensor, and the features of vortex-profile interaction were clarified by examining the time evolution of velocity fields, and distributions of the wall pressure coefficient and the lift coefficient. B.J.

A91-19596
MEASUREMENT OF THE SIX AERODYNAMIC COEFFICIENTS IN TRANSIENT FLOW [MESURES D'EFFORTS SIX COMPOSANTES EN ECOULEMENT TRANSITOIRE]
MARC STOJANOWSKI AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 35 p. In French.
(AAAF PAPER NT 89-01) Copyright

A method to correct for inertia on the basis of accelerometric measurements is developed in order to establish precise measurements of the six aerodynamic coefficients in transient unsteady hypersonic flow. The principal problems encountered are discussed and the experimental procedures are then described. Satisfactory results are shown for the longitudinal components, especially where the anticipated effects are observed. In accordance with these results, this methodology is being redirected to study new shapes for the Hermes in order to optimize the accelerometric adjustments. R.E.P.

N91-13400*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CLOSE-RANGE PHOTOGRAMMETRIC MEASUREMENT OF STATIC DEFLECTIONS FOR AN AEROELASTIC SUPERCRITICAL WING
THOMAS A. BYRDSONG, RICHARD R. ADAMS, and MAYNARD C. SANDFORD Washington Dec. 1990 93 p
(NASA-TM-4194; L-16720; NAS 1.15:4194) Avail: NTIS HC/MF A05 CSCL 01A

Close range photogrammetric measurements were made for the lower wing surface of a full span aspect ratio 10.3 aeroelastic supercritical research wing. The measurements were made during wind tunnel tests for quasi-steady pressure distributions on the wing. The tests were conducted in the NASA Langley Transonic Dynamics Tunnel at Mach numbers up to 0.90 and dynamic

pressures up to 300 pounds per square foot. Deflection data were obtained for 57 locations on the wing lower surface using dual non-metric cameras. Representative data are presented as graphical overview to show variations and trends of spar deflection with test variables. Comparative data are presented for photogrammetric and cathetometric results of measurements for the wing tip deflections. A tabulation of the basic measurements is presented in a supplement to this report. Author

N91-13401*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NAVIER-STOKES AND EULER SOLUTIONS FOR LEE-SIDE FLOWS OVER SUPERSONIC DELTA WINGS. A CORRELATION WITH EXPERIMENT
S. NAOMI MCMILLIN, JAMES L. THOMAS, and EARLL M. MURMAN (Massachusetts Inst. of Tech., Cambridge.) Washington Dec. 1990 103 p Original contains color illustrations
(NASA-TP-3035; L-16751; NAS 1.60:3035) Avail: NTIS HC/MF A06; 19 functional color pages CSCL 01A

An Euler flow solver and a thin layer Navier-Stokes flow solver were used to numerically simulate the supersonic leeside flow fields over delta wings which were observed experimentally. Three delta wings with 75, 67.5, and 60 deg leading edge sweeps were computed over an angle-of-attack range of 4 to 20 deg at a Mach number 2.8. The Euler code and Navier-Stokes code predict equally well the primary flow structure where the flow is expected to be separated or attached at the leading edge based on the Stanbrook-Squire boundary. The Navier-Stokes code is capable of predicting both the primary and the secondary flow features for the parameter range investigated. For those flow conditions where the Euler code did not predict the correct type of primary flow structure, the Navier-Stokes code illustrated that the flow structure is sensitive to boundary layer model. In general, the laminar Navier-Stokes solutions agreed better with the experimental data, especially for the lower sweep delta wings. The computational results and a detailed re-examination of the experimental data resulted in a refinement of the flow classifications. This refinement in the flow classification results in the separation bubble with the shock flow type as the intermediate flow pattern between separated and attached flows. Author

N91-13402*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF LOCATION OF AFT-MOUNTED NACELLES ON THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A HIGH-WING TRANSPORT AIRPLANE
WILLIAM K. ABEYOUNIS and JAMES C. PATTERSON, JR. (Vigyan Research Associates, Inc., Hampton, VA.) Washington Dec. 1990 98 p
(NASA-TP-3047; L-16743; NAS 1.60:3047) Avail: NTIS HC/MF A05 CSCL 01A

As part of a propulsion/airframe integration program at Langley Research Center, tests were conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of locating flow-through mixed flow engine nacelles in several aft underwing positions on the longitudinal aerodynamics of a high wing transport airplane. D-shaped inlet nacelles were used in the test. Some configurations with antishock bodies and with nacelle toe-in were also tested. Data were obtained for a free stream Mach number range of 0.70 to 0.85 and a model angle-of-attack range from -2.5 to 4.0 degrees. Author

N91-13404*# Georgia Inst. of Tech., Atlanta. Flight Mechanics and Control.
ANALYTICAL AERODYNAMIC MODEL OF A HIGH ALPHA RESEARCH VEHICLE WIND-TUNNEL MODEL
JICHANG CAO, FREDERICK GARRETT, JR., ERIC HOFFMAN, and HAROLD STALFORD Sep. 1990 127 p
(Contract NAG1-959)
(NASA-CR-187469; NAS 1.26:187469) Avail: NTIS HC/MF A07 CSCL 01A

A 6 DOF analytical aerodynamic model of a high alpha research vehicle is derived. The derivation is based on wind-tunnel model data valid in the altitude-Mach flight envelope centered at 15,000 ft altitude and 0.6 Mach number with Mach range between 0.3 and 0.9. The analytical models of the aerodynamics coefficients are nonlinear functions of alpha with all control variable and other states fixed. Interpolation is required between the parameterized nonlinear functions. The lift and pitching moment coefficients have unsteady flow parts due to the time range of change of angle-of-attack (alpha dot). The analytical models are plotted and compared with their corresponding wind-tunnel data. Piloted simulated maneuvers of the wind-tunnel model are used to evaluate the analytical model. The maneuvers considered are pitch-ups, 360 degree loaded and unloaded rolls, turn reversals, split S's, and level turns. The evaluation finds that (1) the analytical model is a good representation at Mach 0.6, (2) the longitudinal part is good for the Mach range 0.3 to 0.9, and (3) the lateral part is good for Mach numbers between 0.6 and 0.9. The computer simulations show that the storage requirement of the analytical model is about one tenth that of the wind-tunnel model and it runs twice as fast. Author

N91-13406*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC EFFECT OF STRAKES ON TWO-DIMENSIONAL TAIL BOOM MODELS OF THE OH-58A AND THE OH-58D HELICOPTERS
CYNTHIA A. CROWELL and HENRY L. KELLEY (Army Aerostructures Directorate, Hampton, VA.) Washington Dec. 1990 34 p
(Contract DA PROJ. 1L1-62211-A-47-A)
(NASA-TM-4248; L-16842; NAS 1.15:4248;
AVSCOM-TR-90-B-010) Avail: NTIS HC/MF A03 CSCL 01A

During hover and low speed flight, helicopters experience significant aerodynamic forces on the tail boom caused by the wake from the main and tail rotors and by crosswinds. These effects were simulated during a study conducted in the Langley 14 by 22 Foot Subsonic Tunnel on a 136 percent scaled 2-D tail boom model with cross sections representative of those on the U.S. Army OH-58A and the OH-58D helicopters. The effects of longitudinal strakes attached to the cross sections were studied. To obtain the aerodynamic forces acting on the cross sections, the flow incidence range on the scaled models was varied from -45 to 90 degrees and the models were tested through a dynamic pressure range of 5 to 15 psf. The results of the OH-58A and the OH-58D configurations show a significant improvement at conditions which represent right sideward flight by reducing the adverse aerodynamic side force when the strakes are installed. These data were used to calculate a change in tail rotor power for the full scale flight vehicle and indicated approx. a 5 to 6 percent average savings in right sideward flight for the critical velocity range of 0 to 30 knots. Increases in the tail boom normal force were noted due to the strakes. The results indicate a potential for reducing the directional control and tail rotor thrust required in the critical hover and right sideward flight speed range with a calculated minimum increase to main rotor power required and an overall net improvement in power of 0.5 percent for both the OH-58A and OH-58D. Author

N91-13407 Georgia Inst. of Tech., Atlanta.
DEVELOPMENT OF A FULL POTENTIAL SOLVER FOR ROTOR AERODYNAMICS ANALYSIS Ph.D. Thesis
DEVON S. PRICHARD 1990 210 p
Avail: Univ. Microfilms Order No. DA9031268

A computer program for calculating the unsteady, three-dimensional transonic potential flow about isolated rotor blades was developed. This method calculates the nearfield aerodynamics of arbitrarily shaped rotor blades by solving a conservative form of the unsteady full potential equations on a body-fitted grid. The application of this code to rotor flow problems was extended through the development of improved blade dynamics and farfield wake modeling, and incorporation of boundary layer modeling in the flow solution. Evaluation of the full potential

solver applied to rotor problems and evaluations of the blade motion and boundary layer works are presented. Dissert. Abstr.

N91-13409# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.
THE IAR HIGH REYNOLDS NUMBER TWO-DIMENSIONAL TEST FACILITY: A DESCRIPTION OF EQUIPMENT AND PROCEDURES COMMON TO MOST 2-D AIRFOIL TESTS
R. D. GALWAY Jun. 1990 53 p
(AD-A226629; IAR-AN-66; NRC-32132) Avail: NTIS HC/MF A04 CSCL 14/2

Features and operational procedures are described which are common to the great majority of wind tunnel test projects conducted in the Two-Dimensional (2-D) Test Facility of the Institute of Aerospace Research (IAR) 1.5 m Trisonic Blowdown Wind Tunnel in Ottawa, Canada. The 'facility specific' aspects of tests performed in the above facility are described along with test reports for individual projects which concentrate on aspects which are specific to the particular model and test. The 2-D test facility as modernized by the commissioning of a new interchangeable 2-D test section module in early 1989 is described in detail. GRA

N91-13411*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOME OBSERVATIONS ON THE HOUBOLT-RAINEY AND PEAK-HOLD METHODS OF FLUTTER ONSET PREDICTION
ROBERT V. DOGGETT, JR. Nov. 1990 12 p
(NASA-TM-102745; NAS 1.15:102745) Avail: NTIS HC/MF A03 CSCL 01/1

A subcritical response method for flutter onset prediction developed by Houbolt and Rainey in 1958 is compared with the Peak-Hold Method which was apparently first applied to flutter onset prediction by Sandford, Abel, and Gray in the early 1970's. The rational argument presented shows that the two methods are not different, but are actually the same. So, because there is an analytical foundation for the Houbolt-Rainey Method, then there is the same analytical foundation for the Peak-Hold Method. Further, it is suggested that, in applying Peak-Hold Method in cases where turbulence is used as the excitation force, the variation of the reciprocal of the response amplitude with the reciprocal of the dynamic pressure to be used to extrapolate to flutter onset rather than the variation with dynamic pressure which is the current practice because the linear trend which is predicted to occur for the former is easier to extrapolate to the flutter condition than the nonlinear trend predicted to occur for the latter. Author

N91-13412*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOME BUFFET RESPONSE CHARACTERISTICS OF A TWIN-VERTICAL-TAIL CONFIGURATION
STANLEY R. COLE, STEVEN W. MOSS, and ROBERT V. DOGGETT, JR. Oct. 1990 25 p Prepared in cooperation with Arnold Engineering Development Center, Arnold Air Force Station, TN
(NASA-TM-102749; NAS 1.15:102749) Avail: NTIS HC/MF A03 CSCL 01/1

A rigid, 1/6 size, full span model of an F-18 airplane was fitted with flexible vertical tails of two different levels of stiffness that were buffet tested in the Langley Transonic Dynamics Tunnel. Vertical tail buffet response results that were obtained over the range of angles of attack from -10 to 40 degs, and over the range of Mach numbers from 0.30 to 0.95 are presented. These results indicate the following: (1) the response occurs in the first bending mode; (2) the response increases with increasing dynamic pressure, but changes in response are not linearly proportional to the changes in dynamic pressure; (3) the response is larger at M = 0.30 than it is at the higher Mach numbers; (4) the maximum intensity of the buffeting is described as heavy to severe using an assessment criteria proposed by another investigator; and (5) the data at different dynamic pressures and for the different tails correlate reasonably well using the buffet excitation parameter derived from the dynamic analysis of buffeting. Author

N91-13415# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abt. Flugmechanik der Drehfluegelflugzeuge.
ANALYTIC FORMULATIONS OF UNSTEADY PROFILE AERODYNAMICS AND ITS APPLICATION TO SIMULATION OF ROTORS
BEREND VANDERWALL Mar. 1990 117 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1244)
(DLR-FB-90-28; ISSN-0171-1342; ETN-91-98260; ESA-TT-1244) Avail: NTIS HC/MF A06; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, HC 42 DM

A new way of modeling rotor aerodynamics is presented using a set of formulas describing the steady aerodynamic behavior of a profile. It offers the possibility to transfer the periodically changing velocities at the profile to an also periodically changing phase lag of angle of attack and dynamic stall effect directly in simulation. A model method is used for the description of blade dynamics. Induced velocities are formulated by a prescribed distorted spiral geometry, fitting well with measurements. Results show that this configuration is a good compromise between short calculation time requirements and accuracy of results, especially for higher harmonic control calculations. ESA

N91-13416# Aeronautical Research Inst. of Sweden, Stockholm. Dept. of Aerodynamics.
TRANSONIC WIND TUNNEL TESTS ON TWO-DIMENSIONAL AEROFOIL SECTIONS: DETERMINATION OF PRESSURE DISTRIBUTION AND DRAG FOR AN AEROFOIL OF TYPE SAAB 7301 IN FFA WIND TUNNEL S5
GOERAN EHN Dec. 1989 160 p
(Contract FMV-82223-72-004)
(FFA-TN-1989-47; ETN-91-98265) Avail: NTIS HC/MF A08

A symmetrical two dimensional airfoil model was investigated in a 0.25 sq m wind tunnel. The airfoil profile has a relative thickness of 12 percent at 40 percent of the chord. It is constructed to have shock free flow at the design Mach number M equals 0.7966, with a maximum local Mach number of M equals 1.104. The test program included airfoil pressure distribution measurements and wake drag measurements in the Mach number range M situated between 0.5 and 0.86 for angles of attack degrees alpha situated between -4 and 4. Boundary layer transition from laminar to turbulent was done by means of transition trips and was visualized by sublimation tests. The best agreement with the predicted C sub p curve is found for M equals 0.81 and alpha equals 0.2 degree. ESA

N91-13417# Aeronautical Research Inst. of Sweden, Stockholm. Dept. of Structures.
FE ANALYSES OF AIRCRAFT MODEL WITH INTERIOR TRIM
PETER GOERANSSON (Ingemanssons Ingenjoersbyraa A.B., Goteborg, Sweden) Sep. 1990 57 p Sponsored by Swedish Technical Board of Development Original contains color illustrations
(FFA-TN-1990-21; ETN-91-98267) Avail: NTIS HC/MF A04

A finite element (FE) analysis of the dynamic behavior of an aircraft fuselage with interior trim panels was performed. The FE model used is a half model of the fuselage shell, the trim panels, the acoustic cavity in between the two shells, and the interior acoustic cavity. For the present model, the eigenvalues and eigenmodes between 50 and 100 Hz are shown and observations regarding fluid structure interactions are made. The influence of the trim acoustic cavity is demonstrated through both a substantial resonance frequency shifting and an increased transmission. ESA

N91-13418 Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
INFLUENCE OF THERMODYNAMICAL MODELIZATION FOR CHEMICALLY REACTING AIR FLOW Thesis - Tech. Univ. Munich [EINFLUSS THERMODYNAMISCHER MODELLIERUNGEN FUER STROEMUNGEN VON CHEMISCH REAGIERENDER LUFT]

R. BAREISS 7 May 1990 94 p In GERMAN
(MBB/FE122/S/PUB/400; ETN-91-98381) Copyright Avail: Fachinformationszentrum Karlsruhe 2, 7514 Eggenstein-Leopoldshaffen, Fed. Republic of Germany

As a heat protection system of an hypersonic aircraft takes a great part in its total mass, the flow field has to be known as exactly as possible for an optical design. The flow field is calculated numerically, because the simulation in wind channels is not possible in all flight ranges. The real gas effects, the flow chemical equilibrium, were already taken into consideration especially for flight heights inferior to 5 km. For greater flight heights, the chemical nonequilibrium effects are of interest. The influence of various modelizations on the flow and on the calculation time needed, was examined for three calculation cases: heat bath, perpendicular shock, and one-dimensional nozzle flow. The available models are essential for the calculation of chemical nonequilibrium flows. They confirm the importance of chemical nonequilibrium. For the modelization, it is shown that the exchange reactions are notably more important than the dissociation reactions. ESA

N91-13420*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A STEADYING EFFECT OF ACOUSTIC EXCITATION ON TRANSITORY STALL

K. B. M. Q. ZAMAN 1991 17 p Proposed for presentation at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(NASA-TM-103689; E-5908; NAS 1.15:103689; AIAA-91-0043) Avail: NTIS HC/MF A03 CSCL 01/1

The effect of acoustic excitation on a class of separated flows with a transitional boundary layer at the point of separation is considered. Experimental results on the flow over airfoils, a two-dimensional backward-facing step, and through large angle conical diffusers are presented. In all cases, the separated flow undergoes large amplitude fluctuations, much of the energy being concentrated at unusually low frequencies. In each case, an appropriate high frequency acoustic excitation is found to be effective in reducing the fluctuations substantially. The effective excitation frequency scales on the initial boundary layer thickness and the effect is apparently achieved through acoustic tripping of the separating boundary layer. Author

N91-13421*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A REVIEW OF ICE ACCRETION DATA FROM A MODEL ROTOR ICING TEST AND COMPARISON WITH THEORY

RANDALL K. BRITTON (Sverdrup Technology, Inc., Brook Park, OH.) and THOMAS H. BOND 1991 35 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(Contract NAS3-25266)
(NASA-TM-103712; E-5930; NAS 1.15:103712; AIAA-91-0661) Avail: NTIS HC/MF A03 CSCL 01/1

An experiment was conducted by the Helicopter Icing Consortium (HIC) in the NASA Lewis Icing Research Tunnel (IRT) in which a 1/6 scale fuselage model of a UH-60A Black Hawk helicopter with a generic rotor was subjected to a wide range of icing conditions. The HIC consists of members from NASA, Bell Helicopter, Boeing Helicopter, McDonnell Douglas Helicopters, Sikorsky Aircraft, and Texas A&M University. Data was taken in the form of rotor torque, internal force balance measurements, blade strain gage loading, and two dimensional ice shape tracings. A review of the ice shape data is performed with special attention given to repeatability and correctness of trends in terms of radial variation, rotational speed, icing time, temperature, liquid water content, and volumetric median droplet size. Moreover, an indepth comparison between the experimental data and the analysis of NASA's ice accretion code LEWICE is given. Finally, conclusions are drawn as to the quality of the ice accretion data and the predictability of the data base as a whole. Recommendations are also given for improving data taking technique as well as potential future work. Author

N91-13422*# Minnesota Univ., Minneapolis. Dept. of Aerospace Engineering and Mechanics.

TRANSONIC BLADE-VORTEX INTERACTIONS NOISE: A PARAMETRIC STUDY

A. S. LYRINTZIS and Y. XUE 1990 37 p Presented at the 46th AHS Annual Forum, Washington, DC, 21-23 May 1990
(Contract NAG2-588)
(NASA-CR-187713; NAS 1.26:187713) Avail: NTIS HC/MF A03 CSCL 01/1

Transonic Blade-Vortex Interactions (BVI) are simulated numerically and the noise mechanisms are investigated. The 2-D high frequency transonic small disturbance equation is solved numerically (VTRAN2 code). An Alternating Direction Implicit (ADI) scheme with monotone switches is used; viscous effects are included on the boundary and the vortex is simulated by the cloud-in-cell method. The Kirchoff method is used for the extension of the numerical 2-D near field aerodynamic results to the linear acoustic 3-D far field. The viscous effect (shock/boundary layer interaction) on BVI is investigated. The different types of shock motion are identified and compared. Two important disturbances with different directivity exist in the pressure signal and are believed to be related to the fluctuating lift and drag forces. Noise directivity for different cases is shown. The maximum radiation occurs at an angle between 60 and 90 deg below the horizontal for an airfoil fixed coordinate system and depends on the details of the airfoil shape. Different airfoil shapes are studied and classified according to the BVI noise produced. Author

N91-14274*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLOW VISUALIZATION STUDIES OF BLOWING FROM THE TIP OF A SWEPT WING

JEANNETTE W. SMITH, RAYMOND E. MINECK, and DAN H. NEUHART (Lockheed Engineering and Sciences Co., Hampton, VA.) Washington Nov. 1990 31 p Original contains color illustrations
(NASA-TM-4217; L-16767; NAS 1.15:4217) Avail: NTIS HC/MF A03; 8 functional color pages CSCL 01/1

Flow visualization studies of blowing from the tip of a swept wing were conducted in the Langley 16- by 24-inch water tunnel. Four wing tips, each with two independent blowing slots, were tested. The two slots were located one behind the other in the chordwise direction. The wing tips were designed to vary systematically the jet length, the jet in-plane exhaust direction (sweep), and the jet out-of-plane exhaust direction (anhedral). Each blowing slot was tested separately at two angles of attack and at four ratios of jet to free stream velocity ratios. Limited tests were conducted with blowing from both slots simultaneously. Blowing from the tip inhibited inboard spanwise flow on the upper wing surface near the tip. The jet path moved farther away from the tip with increasing jet to free stream velocity ratio and moved closer to the tip with increasing angle of attack. Author

N91-14275*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INTERNAL PERFORMANCE OF A HYBRID AXISYMMETRIC/NONAXISYMMETRIC CONVERGENT-DIVERGENT NOZZLE

JOHN G. TAYLOR Washington Jan. 1991 57 p
(NASA-TM-4230; L-16816; NAS 1.15:4230) Avail: NTIS HC/MF A04 CSCL 01/1

An investigation was conducted in the static test facility of the Langley 16-foot transonic tunnel to determine the internal performance of a hybrid axisymmetric/nonaxisymmetric nozzle in forward-thrust mode. Nozzle cross-sections in the spherical convergent section were axisymmetric whereas cross-sections in the divergent flap area nonaxisymmetric (two-dimensional). Nozzle concepts simulating dry and afterburning power settings were investigated. Both subsonic cruise and supersonic cruise expansion ratios were tested for the dry power nozzle concepts. Afterburning power configurations were tested at an expansion ratio typical for subsonic acceleration. The spherical convergent flaps were designed in such a way that the transition from axisymmetric to

nonaxisymmetric cross-section occurred in the region of the nozzle throat. Three different nozzle throat geometries were tested for each nozzle power setting. High-pressure air was used to simulate jet exhaust at nozzle pressure ratios up to 12.0. Author

N91-14290# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Experimentelle Stroemungsmechanik.
SYSTEMATIC INVESTIGATIONS OF BODY-WING-TAIL INTERFERENCE AT HIGH ANGLES OF ATTACK
K. HARTMANN and D. NIKOLITSCH (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, Germany, F.R.) *In* AGARD, Missile Aerodynamics 16 p Oct. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Six component measurements were carried out on several combinations of an ogive-circular cylinder body without and with lifting surfaces having rectangular planform and sharp leading and trailing edges. These experiments were performed in the subsonic compressible speed range at various Reynolds numbers up to high angles of attack. For the same geometries the forces and moments were calculated and compared with the experimental results. It was the aim of this combined investigation to get a better understanding of the vortex flows over such body-wing-tail combinations and to generate a reliable data base for the validation and improvement of prediction methods and to obtain hints for a more accurate theoretical modeling of the flow fields. Author

N91-14292*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ASYMMETRIC SUPERSONIC FLOW AROUND CONES WITH NONCIRCULAR SECTIONS
OSAMA A. KANDIL, TIN-CHEE WONG (Old Dominion Univ., Norfolk, VA.), and C. H. LIU *In* AGARD, Missile Aerodynamics 11 p Oct. 1990
(Contract NAS1-18584)
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/1

The unsteady, compressible, single and double thin-layer, Navier-Stokes equations are used to solve for steady and unsteady, asymmetric, supersonic flow around pointed bodies with noncircular sections at high incidence and zero side slip. The equations are solved by using an implicit, upwind, flux-difference splitting finite-volume scheme. Since the flow is locally conical, the solutions are presented on a cross-flow plane at the axial station of unit. The grid is generated by using a modified Joukowski transformation. The computational applications cover noncircular sections with elliptic and diamond shapes. Unsteady asymmetric vortex shedding has been captured at large angles of attack. It is shown that for the same flow conditions and same cross-section fineness ratio, the diamond-section cones develop less flow asymmetry than the elliptic-section cones. Passive control of flow asymmetry was also demonstrated computationally. Author

N91-14293# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
COMPARISON OF DIFFERENT CALCULATION METHODS APPLIED TO A LENTICULAR FUSELAGE SECTION [COMPARASON DE DIFFENENTES METHODES DE CALCUL APPLIQUEES A UN FUSELAGE DE SECTION LENTICULAIRE]
P. DESPINEY *In* AGARD, Missile Aerodynamics 15 p Oct. 1990 In FRENCH; ENGLISH summary
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Measurements on a non-circular body were made in the ONERA wind tunnels. This model representative of non-conventional missile shapes, was studied for Mach numbers from 0.4 to 4.5, angles of attack up to 20 deg and sideslip angles up to 10 deg. The data base mainly consists of wall static pressure measurements but also of flowfield measurements at Mach number 2 for angles of attack 10 deg and 20 deg. Comparisons between calculations and experiments obtained with different codes are reported: SHABP (a semi-empirical prediction method), ECOPAN, HISSS (panel method), and FLU3C (Euler method). After a brief survey of the codes their advantages and drawbacks in terms of accuracy and cost-time are shown. Author

N91-14309*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RESULTS OF A SUB-SCALE MODEL ROTOR ICING TEST
ROBERT J. FLEMMING, THOMAS H. BOND, and RANDALL K. BRITTON (Sverdrup Technology, Inc., Brook Park, OH.) 1991 31 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(NASA-TM-103709; E-5935; NAS 1.15:103709; AIAA-91-0660)
Avail: NTIS HC/MF A03 CSCL 01/1

A heavily instrumented sub-scale model of a helicopter main rotor was tested in the NASA Lewis Research Center Icing Research Tunnel (IRT) in September and November 1989. The four-bladed main rotor had a diameter of 1.83 m (6.00 ft) and the 0.124 m (4.9 in) chord rotor blades were specially fabricated for this experiment. The instrumented rotor was mounted on a Sikorsky Aircraft Powered Force Model, which enclosed a rotor balance and other measurement systems. The model rotor was exposed to a range of icing conditions that included variations in temperature, liquid water content, and median droplet diameter, and was operated over ranges of advance ratio, shaft angle, tip Mach number (rotor speed) and weight coefficient to determine the effect of these parameters on ice accretion. In addition to strain gage and balance data, the test was documented with still, video, and high speed photography, ice profile tracings, and ice molds. The sensitivity of the model rotor to the test parameters, is given, and the result to theoretical predictions are compared. Test data quality was excellent, and ice accretion prediction methods and rotor performance prediction methods (using published icing lift and drag relationships) reproduced the performance trends observed in the test. Adjustments to the correlation coefficients to improve the level of correlation are suggested. Author

N91-14310*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL SIMULATION OF ICE GROWTH ON A MS-317 SWEPT WING GEOMETRY
M. G. POTAPCZUK and C. S. BIDWELL Jan. 1991 24 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored in part by AIAA
(NASA-TM-103705; E-5928; NAS 1.15:103705; AIAA-91-0263)
Avail: NTIS HC/MF A03 CSCL 01/1

An effort to develop a 3-D ice accretion modeling method was initiated. This first step towards creation of a complete aircraft icing simulation code builds on previously developed methods for calculating 3-D flow fields and particle trajectories combined with a 2-D ice accretion calculation along coordinate locations corresponding to streamlines. The types of calculations necessary to predict 3-D ice accretion is demonstrated. Results of calculations using 3-D method for a MS-317 swept wing geometry are projected onto a 2-D plane parallel to the free stream direction and compared to experimental results for the same geometry. It is anticipated that many modifications will be made to this approach, however this effort will lay the groundwork for future modeling efforts. Results indicate that rime ice shapes indicate a difficulty in accurately calculating the ice shape in the runback region. Author

N91-14311*# Johnson Aeronautics, Palo Alto, CA.
FEASIBILITY INVESTIGATION OF GENERAL TIME-DOMAIN UNSTEADY AERODYNAMICS OF ROTORS
WAYNE JOHNSON Oct. 1990 220 p
(Contract NAS2-13125)
(NASA-CR-177570; A-90304; NAS 1.26:177570) Avail: NTIS HC/MF A10 CSCL 01/1

The feasibility of a general theory for the time-domain unsteady aerodynamics of helicopter rotors is investigated. The wake theory gives a linearized relation between the downwash and the wing bound circulation, in terms of the impulse response obtained directly

in the time domain. This approach makes it possible to treat general wake configurations, including discrete wake vorticity with rolled-up and distorted geometry. The investigation establishes the approach for model order reduction; determines when a constrained identification method is needed; verifies the formulation of the theory for rolled-up, distorted trim wake geometry; and verifies the formulation of the theory for wake geometry perturbations. The basic soundness of the approach is demonstrated by the results presented. A research program to complete the development of the method is outlined. The result of this activity will be an approach for analyzing the aeroelastic stability and response of helicopter rotors, while retaining the important influence of the complicated rotor wake configuration. Author

N91-14312# Naval Postgraduate School, Monterey, CA.
NUMERICAL STUDIES OF COMPRESSIBLE FLOW OVER A DOUBLE-DELTA WING AT HIGH ANGLES OF ATTACK M.S. Thesis
RAYMOND L. COUTLEY Mar. 1990 171 p
(AD-A226931) Avail: NTIS HC/MF A08 CSCL 01/1

The objective of this work is the investigation of vortical flows at high angles of attack using numerical techniques. The first step for a successful application of a numerical technique, such as finite difference or finite volume, is the generation of a computational mesh which can capture adequately and accurately the important physics of the flow. Therefore, the first part of this work deals with the grid generation over a double-delta wing and the second part deals with the visualization of the computed flow field over the double-delta wing at different angles of attack. The surface geometry of the double-delta wing is defined algebraically. The developed surface grid generator provides flexibility in distributing the surface points along the axial and circumferential directions. The hyperbolic grid generation method is chosen for the field grid generation and both cylindrical and spherical grids are constructed. The computed low speed (M = 0.2) flow results at different angles of attack over the double-delta wing are visualized. Important flow characteristics of the leeward side flow field are discussed while the development of vortex interaction, occurrence and progression of vortex breakdown as the angle of attack increases is demonstrated. The computed results at different fixed angles of attack are presented. GRA

N91-14313# Air Force Academy, CO.
AN EXPERIMENTAL INVESTIGATION INTO THE USE OF HOT-FILM ANEMOMETRY TO MEASURE VORTICAL VELOCITY BEHIND A PITCHING WING
C. BRUCE HARMON and WILLIAM DIETERICH Aug. 1990 17 p
(Contract AF PROJ. 2307)
(AD-A227177; FJSRL-TR-90-0002) Avail: NTIS HC/MF A03 CSCL 14/2

Much has been done in the instrumentation of airfoils and wings to obtain surface pressure data in support of the characterization of the transient lift augmentation due to unsteady aerodynamic effects. These effects have usually been the result of rapidly rotating wings to high angles of attack or periodic oscillation. Integration of the acquired pressure coefficients leads to the airfoil or wing coefficient of lift. Researchers Walker and Robinson asked for other researchers to explore the use of hot-film anemometry as a confirming technique. In such a role, the anemometry is capable of mapping velocity vs. position, which is used to compute circulation via a line integral. The computed circulation is directly proportional to lift coefficient for a given freestream velocity. The investigation is described into the use of hot-film anemometry, strengths and weaknesses of the approach are identified, and specific recommendations are made regarding its use. GRA

N91-14315# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
CONTROL OF UNSTEADY AERODYNAMIC FORCES Final Report, 1 May 1988 - 30 Apr. 1990
CHIH-MING HO 26 Jul. 1990 67 p
(Contract F49620-88-C-0061)
(AD-A227365; AFOSR-90-0924TR) Avail: NTIS HC/MF A04 CSCL 01/1

The aerodynamic properties of an airfoil under unsteady conditions are very different from ones in steady conditions because the vortex generated by unsteady separation greatly modifies the loading on the wing. In this study, a fundamental approach was taken to investigate the lift and the velocity field of unsteady airfoils. GRA

N91-14316*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PARAMETRIC STUDY OF AFTERBODY/NOZZLE DRAG ON TWIN TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLES AT MACH NUMBERS FROM 0.60 TO 1.20
ODIS C. PENDERGRAFT, JR., JAMES R. BURLEY, II, and E. ANN BARE Oct. 1986 267 p
(NASA-TP-2640; L-16158; NAS 1.60:2640) Avail: NTIS HC/MF A12 CSCL 01/1

An investigation has been conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of upper and lower external nozzle flap geometry on the external afterbody/nozzle drag of nonaxisymmetric two-dimensional convergent-divergent exhaust nozzles having parallel external sidewalls installed on a generic twin-engine, fighter-aircraft model. Tests were conducted over a Mach number range from 0.60 to 1.20 and over an angle-of-attack range from -5 to 9 deg. Nozzle pressure ratio was varied from jet off (1.0) to approximately 10.0, depending on Mach number. Author

N91-14331# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Aeroelasticity.
UNSTEADY AERODYNAMIC FORCES ON AN OSCILLATING WING AT HIGH INCIDENCES AND FLOW SEPARATION
H. W. FOERSCHING *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 18 p Sep. 1990
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Based on wind tunnel measurements on a low-aspect-ratio trapezoidal half-wing model in incompressible flow, some characteristic features of motion-induced unsteady airloads at high incidences and flow separation are presented and discussed. Special emphasis is placed on the effect of the motion of the wing on the flow separation processes and on the investigation of the interactions between the separated flow phenomena on the stationary wing and the motion-induced unsteady airloads on the oscillating wing. It is shown that these airloads are strongly affected by the flow separations and that their prediction from inviscid potential-flow theory may lead to rather unrealistic results in buffeting response calculations. Author

N91-14340*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY AIRLOADS DUE TO SEPARATED FLOW ON AIRFOILS AND WINGS
JOHN W. EDWARDS *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 18 p Sep. 1990 Previously announced in IAA as A90-33311
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/1

Experimental and computational studies of airloads due to separated flows over airfoils and wings conducted at the NASA Langley Research Center are surveyed. Results are presented for cases involving local flow separation such as shock-induced separation, for the initiation of leading-edge vortex flows, and for cases involving unsteady airloads due to flows separating over remote aircraft components. Good correlation is obtained between experiment and computation for cases of locally separating flow and steady computations of vortex flow over delta wings and complex forebody geometries are shown. Physical flow modeling issues and computational requirements for the case of vertical tail buffeting are developed. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A91-17173
PROBABILITY CHARACTERISTICS OF AIRCRAFT STRUCK BY LIGHTNING [VEROIATNOSTNYE KHARAKTERISTIKI PORAZHENIIA MOLNIEI LETATEL'NYKH APPARATOV]
M. A. ARONOV, V. P. LARIONOV, and T. N. TARASOVA Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Sept.-Oct. 1990, p. 93-100. In Russian. refs
Copyright

Based on the extent of damage incurred on an aircraft by a lightning discharge, the dependence of the probability factor characterizing the flight safety on the statistical characteristics of the storm activity and the lightning parameters is investigated. A ratio between the degree of risk and the degree of safety with respect to lightning is established. Using an assumed standard degree of risk, the degree of safety characterizing the lightning protection systems for the different aircraft components and service conditions can be determined in advance. B.P.

A91-17174
EFFECT OF LIGHTNING ON THE ON-BOARD EQUIPMENT OF FLIGHT VEHICLES [VOZDEISTVIE MOLNII NA BORTOVOE OBORUDOVANIE LETATEL'NYKH APPARATOV]
G. O. AVAKIAN, M. B. BABINOV, R. K. BORISOV, and V. P. LARIONOV Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Sept.-Oct. 1990, p. 101-107. In Russian. refs
Copyright

An analysis is made of experimental and analytical methods for estimating the effect of lightning-induced voltage surges on the on-board equipment of flight vehicles. Results of the ground testing of medium and large cargo aircraft are reported, as are the results of experiments on various models. A method for calculating lightning-induced voltage surges is proposed which includes the calculation of current flow over the surface of the flight vehicle, penetration of the current through the skin and openings, and wave processes within the flight vehicle and connecting circuits. V.L.

A91-17217* Massachusetts Inst. of Tech., Cambridge.
PASSIVE INFRARED ICE DETECTION FOR HELICOPTER APPLICATIONS
ADAM L. DERSHOWITZ and R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 261-265.
(Contract NAG3-927)
Copyright

A technique is proposed to remotely detect rotor icing on helicopters by using passive IR thermometry to detect the warming caused by latent heat release as supercooled water freezes. During icing, the ice accretion region will be warmer than the uniced trailing edge, resulting in a characteristic chordwise temperature profile. Preliminary tests were conducted on a static model in the NASA Icing Research Tunnel for a variety of wet (glaze) and dry (rime) ice conditions. The chordwise temperature profiles were confirmed by observation with an IR thermal video system and thermocouple observations. The IR observations were consistent with predictions of the LEWICE ice accretion code, which was used to extrapolate the observations to rotor icing conditions. Based on the static observations, the passive IR ice detection technique appears promising; however, further testing or rotating blades is required. Author

A91-17218* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ICING TESTS OF A MODEL MAIN ROTOR
THOMAS H. BOND (NASA, Lewis Research Center, Cleveland, OH), ROBERT J. FLEMMING (Sikorsky Aircraft, Stratford, CT), and RANDALL K. BRITTON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 267-281. refs
Copyright

A NASA-sponsored consortium conducted an experimental program to investigate the characteristics of a model rotor under icing conditions. This project resulted in the first U.S. test of a heavily instrumented model rotor conducted in the controlled environment of a refrigerated wind tunnel, the NASA Lewis Icing Research Tunnel. The tunnel entry used a powered force model with a 1.83-m-diameter main rotor, with 0.124-m-chord main rotor blades fabricated specially for this experiment. Test conditions included a range of liquid water content and median volume droplet diameters that fell within the FAA and DOD icing envelopes. The test data show the effects of icing on rotor lift, rotor torque, blade loads, and vibration. Ice shapes and ice dimensions were taken, and molds were made of three ice shapes. High-speed movies were taken to document ice shedding. The results have been compared with analytical accretion predictions. Author

A91-17276
CARGO ROTORCRAFT IN FUTURE ARMY OPERATIONS
THOMAS O. POTTHOFF (U.S. Army, Advanced Systems Concepts Div., Saint Louis, MO), DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta), and GENE R. MARNER IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 931-944. Research sponsored by the U.S. Army. refs
Copyright

A critical evaluation is conducted of past combat-support cargo rotorcraft design criteria, in light of evolving technologies, threats, and tactical doctrines. The tactics encompassed by low- and mid-intensity conflicts entail combat mobility over greater distances, as well as more rapid response for high-priority logistics support, due to the increasing ranges of sensors and weapons. More substantial suppression of radiation signatures and greater protective measures must accordingly be instituted. A tactically acceptable 'largest indivisible load', together with a clear notion of daily transport demand for the range of possible transport situations, must be formulated as bases for the definition of design goals. O.C.

A91-18084
FLIGHT SAFETY [BEZOPASNOST' POLETOV]
RADII V. SAKACH, BORIS V. ZUBKOV, MIKHAIL F. DAVIDENKO, V. N. GOLEGO, N. I. VLADIMIROV et al. Moscow, Izdatel'stvo Transport, 1989, 240 p. In Russian. refs
Copyright

Questions related to the assurance of flight safety are examined using a systems approach. In particular, attention is given to the theoretical fundamentals and organization aspects of flight safety; a systems engineering approach to the prevention of human errors; principles and norms of flight certification; and engineering support. The discussion also covers flight safety under expected and special operation conditions; the use of flight data recording and processing equipment; organization of rescue operations and investigation of aircraft accidents; and preventive measures. V.L.

A91-18525
FLYING VERY LONG DISTANCES WITH TWO ENGINES
TONY WASSELL (Rolls-Royce, PLC, Derby, England) Rolls-Royce Magazine (ISSN 0142-9469), vol. 47, Dec. 1990, p. 22-26.
Copyright

An overview is presented of the background and current status of operating long-distance commercial passenger services with twin-engine aircraft that today are authorized to fly over routes up

to 180 minutes of single-engined flying time distance from suitable airfields. Extended-range twin-engined operations (ETOPS) guidelines have been developed and adopted by both the FAA and the CAA that clear flight plans reducing the distance an airliner must fly, thus saving time and fuel, as well as increasing the payload which can be carried. ETOPS certification falls into two categories, type design approval of the airframe/engine combination and operator/route approval. Also, each operator has to receive approval from its national authority before it is permitted to fly ETOPS schedules over a specific region or route of the world. Some detailed graphs and requirements concerning engine operations are presented. R.E.P.

A91-18916
EXPLOSIVES DETECTION RAISES COMPLEX ISSUES
DUNCAN MACRAE and MICHAEL TAVERNA Aerospace World (ISSN 0983-1592), vol. 4, Nov. 1990, p. 26-32.
Copyright

Critical issues concerning the effectiveness of airport security and, in particular, of explosives detection systems (EDS) are discussed. Various test results of current thermal neutron analysis (TNA) technology, often used in tandem with an X-ray unit, are examined. It is noted that FAA requirements stipulate that the machine must detect 95 percent of all explosives in amounts weighing more than 2.5 kg, although this amount has been cited as being twice as large as the charge responsible for the Lockerbie incident. Test results ranged from complete compliance with these stipulations to merely 65 percent. Vapor detection equipment is noted as one possible effective and inexpensive alternative to TNA technology. The cost and effectiveness of a new generation of X-ray system, the Model 101Z/ZZ Micro Dose, and of computerized tomography technology are also discussed. The impact of EDS screening procedures on airport operations and the need for international standards for EDS procedures are considered. L.K.S.

A91-19205#
THE NEW FAA FLIGHT LOADS MONITORING PROGRAM
TERENCE BARNES (FAA, Washington, DC) and THOMAS DEFIORE (FAA, Atlantic City, NJ) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0258)

The status of the Federal Aviation Administration Flight Load Data Collection Program for collecting repeated-load data on modern transport aircraft is presented. The objectives of the program are to instrument regular in-service aircraft with upgraded data-acquisition equipment to collect new load data in order to determine if the loading spectra being developed for design and test of both small and large aircraft are representative of actual operational usage, and to develop structural design criteria for future generations of small and large aircraft. Focus is placed on airframe-manufacturer load validation, and airborne flight-load data recorder hardware, the recording ground station, data health monitoring, gust- and maneuver-acceleration separation, and derived gust velocities. Updated/enhanced flight and ground processing analysis is also discussed. V.T.

A91-19206#
AVIATION EXPERIMENTS AND THE NOAA WIND PROFILER DEMONSTRATION NETWORK
EDWARD F. HUDSON (Unisys Corp., Great Neck, NY) and JOHN W. HINKELMAN (NCAR, Boulder, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 6 p. refs
(AIAA PAPER 91-0259) Copyright

The Wind Profiler, an unattended Doppler radar detecting and processing returns from the clear air under various weather conditions, is described, along with the NOAA Demonstration Network consisting of 30 Wind Profilers distributed over an area approximately 1500 x 1500 km. Emphasis is placed on preliminary concepts for experiments aimed at quantifying the benefits to aviation that can be realized when networks of Wind Profilers are deployed on an operational basis, nationally and internationally. The experiments grouped into such categories as flight planning, central flow control, enroute air route traffic control, terminal operations, and clear-air turbulence avoidance are discussed. V.T.

A91-19209*# Massachusetts Inst. of Tech., Cambridge.
DETERMINISTIC MULTI-ZONE ICE ACCRETION MODELING
K. YAMAGUCHI, R. J. HANSMAN, JR. (MIT, Cambridge, MA), and M. KAZMIERCZAK (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by FAA, NSF, and Ohio Aerospace Institute. refs
(Contract NAG3-666; NGL-22-009-640)
(AIAA PAPER 91-0265) Copyright

The study focuses on a deterministic model of the surface roughness transition behavior of glaze ice and analyzes the initial smooth/rough transition location, bead formation, and the propagation of the transition location. Based on a hypothesis that the smooth/rough transition location coincides with the laminar/turbulent boundary-layer transition location, a multizone model is implemented in the LEWICE code. In order to verify the effectiveness of the model, ice accretion predictions for simple cylinders calculated by the multizone LEWICE are compared to experimental ice shapes. The glaze ice shapes are found to be sensitive to the laminar surface roughness and bead thickness parameters controlling the transition location, while the ice shapes are found to be insensitive to the turbulent surface roughness. V.T.

A91-19210#
FURTHER DEVELOPMENT OF AN ANTI-ICING RUNBACK MODEL
THEO G. KEITH, JR., KENNETH J. DE WITT (Toledo, University, OH), and KAMEL M. AL-KHALIL AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research sponsored by the General Electric Co. refs
(AIAA PAPER 91-0266) Copyright

A numerical simulation of the anti-icing of aircraft surfaces is presented. The concept of the breakup of a uniformly thin liquid film into individual streams or rivulets separated by dry spaces is used to more accurately describe the physics of the runback water. A two-dimensional heat transfer approach is used to calculate the temperature distributions in the runback water and the solid wall. The model allows a multi-layer representation of the solid wall with the possibility of heating the surface by means of electrical heating elements embedded within the layers, or by means of convective heating of the surface from the inside using compressor bleed air. Parametric studies are performed to investigate the effects of some of the problem variables on the results. Author

A91-19250#
AN EXAMPLE OF THE BEHAVIOR OF AN AIRCRAFT WITH ACCUMULATED ICE - LATENT INSTABILITY
JAMES W. TELFORD (Nevada, University, Reno) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 3 p.
(AIAA PAPER 91-0354) Copyright

This paper describes a well documented aircraft accident in which icing on the non-deiced wing inboard from the twin engine nacelles to the fuselage, lead to instability as a result of fluctuation lift due to this ice accretion. Pitch instability led to unrecoverable deep negative stall resulting in impact and aircraft destruction. Author

A91-19358#
ICING SIMULATIONS USING JONES' DENSITY FORMULA FOR ACCRETED ICE AND LEWICE
M. A. RIOS (U.S. Navy, Naval Air Engineering Center, Lakehurst, NJ) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0556)

An approach for calculating accreted ice density developed by Jones is reviewed, as well as a localized density relationship proposed earlier by Macklin. Enhanced icing effects affecting both Macklin's and Jones' researches are assessed qualitatively.

Subprograms based on Jones' ice density formulation are added to the LEWICE code, and it is shown that ice shapes generated by the Jones-based simulations are closer to experimental shapes and are always larger than shapes generated by Macklin-based simulations. Attention is concentrated on rotational and nonrotational multicylinder effects, vortex shedding, impact velocity, residence time, and density averaging, and such environmental effects as orographic clouds, windspeed variations, and droplet electrical charging are covered. V.T.

A91-19359#
STATISTICAL STUDY OF AIRCRAFT ICING ACCIDENTS
JEFFREY A. COLE and WAYNE R. SAND (NCAR, Boulder, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0558) Copyright

Accidents directly caused by aircraft icing as well as those with aircraft icing as an attributable factor are studied. Orographic, meteorological, and pilot factors that could have had a systematic effect on the icing accidents are statistically examined from the NTSB accident reports. Accident location, aircraft type, operational use, injuries, environmental information, pilot experience level, and the narrative of the accident investigation are considered. The study demonstrates the relationship of orographic features and large bodies of water to the frequency of aircraft icing accidents. It is observed that accidents are equally distributed among takeoff, in-flight, and landing, and that few of general-aviation category aircraft are equipped for flight into known icing conditions. V.T.

A91-19360#
APPLICATION AND SPECIFICATION OF DE-/ANTI-ICING FLUIDS FOR AIRCRAFT WITH DIFFERENT SHORT TAKEOFF TIME AND ROTATION SPEED
RENE SALVADOR (Hoechst AG, Burgkirchen, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0560) Copyright

The effects of deicing and antiicing fluids on small aircraft with a short takeoff time and slow rotation speed are studied. The influence of aerodynamic conditions on the behavior of such fluids are analyzed based on the examination of differences between jets, turboprops, and small aircraft. The viscosity, rheological and aerodynamic performance, and antiicing properties of new thickened de/antiicing fluids for small aircraft with a short takeoff time and slow rotation speed are assessed, and a proposal for the specification of these fluids is presented. It is pointed out that the short-takeoff fluids provide long holdover times and do not require limitations for takeoff speed or time. V.T.

A91-19361#
ICING CHARACTERISTICS OF A HIGH-ALTITUDE LONG-ENDURANCE AIRCRAFT WING AIRFOIL
S. K. IYA and D. E. COOK (Boeing Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0562) Copyright

This paper describes the icing characteristics of a typical high-altitude long-endurance aircraft wing airfoil. The LEWICE ice accretion prediction code was used to predict ice shapes on an unprotected leading edge of a natural laminar flow airfoil. Icing during climb as well as hold segments of a mission were studied. The LEWICE code was also modified to predict sublimation rates for the accreted ice. The predicted ice sublimation rates were very low for high altitude missions, and the estimated time for sublimating all of the accreted ice was in excess of 100 hours. Author

A91-19402*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL INVESTIGATION OF PASSIVE INFRARED ICE DETECTION FOR HELICOPTER APPLICATIONS
ADAM DERSHOWITZ and R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract NAG3-927)
(AIAA PAPER 91-0667) Copyright

A technique is proposed to remotely detect rotor icing on helicopters. Using passive infrared (IR) thermometry it is possible to detect the warming caused by latent heat released as supercooled water freezes. During icing, the ice accretion region on the blade leading edge will be warmer than the uniced trailing edge resulting in a chordwise temperature profile characteristic of icing. Preliminary tests were conducted on a static model in the NASA Icing Research Tunnel for a variety of wet (glaze) and dry (rime) ice conditions. The characteristic chordwise temperature profiles were observed with an IR thermal video system and confirmed with thermocouple measurements. A prototype detector system was built consisting of a single point IR pyrometer, and experiments were run on a small scale rotor model. Again the characteristic chordwise temperature profiles were observed during icing, and the IR system was able to remotely detect icing. Based on the static and subscale rotor tests the passive IR technique is promising for rotor ice detection. Author

A91-19454#
DEVELOPMENT OF AN INTERNATIONAL STANDARD FOR DE-/ANTI-ICING FLUIDS, PROCEDURES AND EQUIPMENT FOR SAFE WINTER OPERATION
R. HORNIG (Deutsche Lufthansa AG, Hamburg, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p.
(AIAA PAPER 91-0758) Copyright

The performance requirements for non-Newtonian, pseudoplastic fluids are described including the hardware test-setups for aerodynamic acceptance as well as anit-icing protection. Operational experiences using non-Newtonian fluids including an overview of the effects of newtonian fluids on aircraft performance are presented. The activities of the Aeronautical Engineer's Association (AEA) are described, AEA recommendations for de-/anti-icing are presented, and a test method for de-/anti-icing fluids is discussed. Progress to date on the internationalization of de-/anti-icing procedures is reviewed, and the role of the International Standardization Organization in the procedures is analyzed. It is noted that other international organizations concerned with this problem include the Society of Automotive Engineers, the Aerospace Industry Association, and the Federal Aviation Administration. L.K.S.

A91-19456#
AIRCRAFT GROUND DEICING, A FLIGHT CREW PERSPECTIVE
DAVID J. HAASE (Air Line Pilots Association, Washington, DC) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0761) Copyright

Aircraft ground deicing methods lack standardization and effectiveness. Flight crew training regarding aircraft ground de/anti-icing is virtually absent. Accident history and incident reports document the seriousness of the problem. The deicing system must assure the 'clean aircraft' concept to provide safe operations. Improvements in training, fluids, procedures and facilities are needed to assure an aerodynamically clean aircraft which will perform in accordance with specifications. SAE and ISO have formed committees to develop improved standards for aircraft deicing. Recommendations for those improved standards are presented from a pilot's perspective. Author

N91-13424*# Boeing Commercial Airplane Co., Seattle, WA.
CIVIL TILTROTOR MISSIONS AND APPLICATIONS Final Report
BILL CLAY, PAUL BAUMGAERTNER, PETE THOMPSON, SAM MEYER, RON REBER, and DENNIS BERRY, ed. Jul. 1987 50 p Original contains color illustrations
(Contract NAS2-12393)
(NASA-CR-177452; NAS 1.26:177452; D6-53878) Avail: NTIS HC/MF A03; 8 functional color pages CSCL 01/3

In 1983, an FAA-sponsored National Rotorcraft Program sought to identify improvements to the national interurban transportation networks and determined that conventional helicopters did not have the potential to satisfy requirements because of a lack of capacity, high operational costs, and high noise levels. Tiltrotors, it was felt offered a better potential to improve interurban air transport service. In 1985, the FAA proposed a joint civil tiltrotor study with NASA and DOD that would capitalize on development of the military V-22 tiltrotor and document the potential of the commercial tiltrotor transport market. The results of a study on the mission and application of a civil tiltrotor is presented. This study addresses national issues and includes a market summary. A technical summary provides information on six design configurations and potential risk areas are identified. The development of a National Plan for a tiltrotor transportation system is recommended including civil tiltrotor technology development, infrastructure planning and development, a flight technology demonstration plan, and near term actions. Author

N91-13425# National Transportation Safety Board, Washington, DC. Office of Aviation Safety.
AIRCRAFT ACCIDENT REPORT: ALOHA ISLANDAIR, INC., FLIGHT 1712, DE HAVILLAND TWIN OTTER, DHC-6-300, N707PV, HALAWA POINT, MOLOKAI, HAWAII, OCTOBER 28, 1989
25 Sep. 1990 43 p
(PB90-910405; NTSB/AAR-90/05) Avail: NTIS HC/MF A03 CSCL 01/3

The crash of Aloha IslandAir flight 1712, a de Havilland Twin Otter DHC-6-300 near Halawa Bay, Molokai, Hawaii, on October 28, 1989, is explained. The safety issues discussed are surveillance of 14 CFR Part 135 operators by the Federal Aviation Administration, 14 CFR Part 135 operating procedures, flight following in the Hawaiian islands, weather, and crew training. Safety recommendations addressing these issues were made to the FAA, the National Weather Service, the Regional Airlines Association, and the Aircraft Owners and Pilots Association. Author

N91-13426# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
AIRPORT STAND ASSIGNMENT MODEL
A. MARAWA and N. J. ASHFORD Jun. 1990 106 p
(TT-9009; ISBN-0-904947-24-6; ETN-91-98357) Copyright Avail: NTIS HC/MF A06

Aircraft delay is outlined as a major source of diseconomy in the air transport system. Stand capacity deficiency is identified as one of its major causes. As physical expansion of stand capacity does not appear to be one of the obvious solutions, it is proposed to seek a cost effective way of managing and operating the existing capacity, and to develop a microcomputer simulation model as an innovative and effective technique to be used in the area of stand allocation, in order to significantly reduce aircraft delays and subsequently increase the overall stand capacity. ESA

N91-13427# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
UK AIRLINES' COST STRUCTURE AND IMPLICATIONS OF AIR TRANSPORT SERVICES FRAGMENTATION. RESEARCH REPORT ON AIR TRANSPORT FRAGMENTATION
N. N. NDOH Aug. 1990 47 p
(TT-9011; ISBN-0-904947-26-2; ETN-91-98358) Copyright Avail: NTIS HC/MF A03

It is proposed to determine the structure of United Kingdom airlines costs, using appropriate models, in order to readdress the arguments for and against fragmentation of air transport services, in particular within a metropolitan hub system of airports. The emphasis is on the supply of services rather than the demand for services. The full cost models estimated for United Kingdom scheduled airlines are attached in an appendix. ESA

N91-14317# Federal Aviation Administration, Atlantic City, NJ.
SMOKE AND EXTINGUISHER AGENT DISSIPATION IN A SMALL PRESSURIZED FUSELAGE Final Report
G. SLUSHER, A. ABRAMOWITZ, and W. NEESE Nov. 1990 43 p
(DOT/FAA/CT-89/31) Avail: NTIS HC/MF A03

A test study was conducted using Halon 1211 and Halon 1301 fire extinguishing agents and aerosol smoke to study their behavior in a pressurized Cessna C-421B aircraft. Halon fire extinguishers were discharged and monitored at various locations to determine the concentrations of neat halon gases present, their dissipation rates and any resultant toxic threat to the occupants. Artificial smoke was also generated at various locations and was measured at three fixed locations in the aircraft, thereby providing localized visibility information as well as ventilation data. Peak halon concentrations were considered adequate to extinguish most fires. Halon dosages for the pilot and copilot were low or zero and those for the passengers were also low in relation to the toxic limits recommended. The high ventilation rates in the cockpit area contributed to clearing smoke from the cockpit quickly. It also prevented the smoke from entering the cockpit when it was released in the passenger cabin. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A91-17363
AN ALTERNATIVE COMMON VIEW METHOD FOR TIME TRANSFER WITH GPS
HENRY F. FLIEGEL (Aerospace Corp., El Segundo, CA), RONALD L. BEARD, G. PAUL LANDIS, and SARAH B. STEBBINS (U.S. Navy, Naval Research Laboratory, Washington, DC) Navigation (ISSN 0028-1522), vol. 37, Fall 1990, p. 263-272. refs
Copyright

The standard method of using GPS to compare the times of distant clocks is called the common view technique, by which two or more ground stations simultaneously observe a single GPS space vehicle (SV). In the most widely used form of common view, the positions of the SVs must be known because the signal transit times must be calculated. However, common view is one form of multilateration, by which solutions can be obtained for the positions of both stations and satellites, as well as clock offsets. It is shown how to adapt the principles from the classical geodetic literature on multilateration to time transfer. The need to optimize the geographic distribution of common view stations and the times of observation are discussed. A proposal for field tests is also presented, based on numerical simulations. Author

A91-17364
A ROTATED-COORDINATE GAUSSIAN POSITION RECONSTRUCTION ALGORITHM FOR THE MICROWAVE LANDING SYSTEM
F. D. POWELL (Mitre Corp., Bedford, MA) Navigation (ISSN 0028-1522), vol. 37, Fall 1990, p. 273-283. Research supported by USAF.
Copyright

The Microwave Landing System (MLS) avionics convert the received signals of range, azimuth angle, and elevation angle to yield aircraft position in Cartesian coordinates relative to a point on the centerline of the selected runway. This enables area navigation, including multileg, curved, and computed centerline approaches. The MLS ground equipment transmitters may be sited in various arrangements relative to the runway; an iterative algorithm is required in the avionics to compute the correct approach path. The size and speed of the algorithm, and its computational burden, affect the MLS avionics storage and timing requirements. The principal candidate algorithms are Gauss-Seidel (GS) and Newton-Raphson (NR) types. The usual GS types may diverge within the minimum MLS coverage, while the NR types

have problems with singularities and multiple solutions, need more storage, and impose a greater computational burden. This paper presents a GS algorithm which, by an ideal rotation of the coordinate system, enables fast convergence everywhere in the maximum MLS coverage. Author

A91-17365
GPS AVAILABILITY. II - EVALUATION OF STATE PROBABILITIES FOR 21 SATELLITE AND 24 SATELLITE CONSTELLATIONS
J.-M. DURAND (CNES, Toulouse, France) and A. CASEAU (Societe Generale de Techniques et d'Etudes, Toulouse, France) Navigation (ISSN 0028-1522), vol. 37, Fall 1990, p. 285-296. refs
Copyright

For a given constellation, GPS availability can be inferred from two fundamental factors: the probability of a constellation being in a given state (number of working satellites), and service availability when the constellation is in that state. The first of these factors are considered by examining the consistency of the data currently being published by the civilian community on GPS system failures and availability. Also, a plausible set of parameters based on a Markov chain model are presented that can then be utilized to determine plausible state probabilities for a 24 satellite constellation. R.E.P.

A91-17436
CAUSAL PROBABILISTIC MODEL FOR EVALUATING FUTURE TRANSOCEANIC AIRLANE SEPARATIONS
H. JAMES ROME and VENKATARAMA KRISHNAN (Lowell, University, MA) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 26, Sept. 1990, p. 804-817. refs
(Contract DTRS-57-85-C-00088)
Copyright

A detailed probability model of aircraft cross-track deviations is required to determine the impact of proposed automatic dependent surveillance (ADS) schemes. A suitable causal probability model is presented where normal navigation, degradation, pilot blunder, and failure are each modeled by Gaussian density functions with mean and standard deviations defined by the physics of the event. The overall model is a weighted sum of the Gaussian error probabilities and is thus amenable to extrapolation. Overlap and encroachment probabilities are derived, and the effct of ADS on this is model-determined. By using a simple form of ADS, separation standards can be reduced, and the transmission of a figure of merit providing information on failures and degradations can further reduce separation standards. The results suggest an improvement by a factor of two from current separation standards. I.E.

A91-18077
AIRBORNE EQUIPMENT OF SHORT-RANGE NAVIGATION RADIO SYSTEMS [BORTOVOE OBORUDOVANIE RADIOSISTEM BLIZHNEI NAVIGATSII]
ANDREI D. TROIANOVSKII, ANSIS M. KLUGA, and BORIS IA. TSIL'KER Moscow, Izdatel'stvo Transport, 1990, 184 p. In Russian. refs
Copyright

The general principles of the design of short-range navigation radio systems are discussed. An analysis is made of range and direction measurement methods and of the main errors of azimuth and range measuring instruments. Particular attention is given to the functional organization and design features of the airborne angle- and range-measuring equipment of short-range navigation systems. The modeling and monitoring of the technical condition of airborne equipment are also discussed. V.L.

A91-19006#
LINEAR HELICOPTER TRACKERS USING ATTITUDE MEASUREMENTS
DOMINICK ANDRISANI, II (Purdue University, West Lafayette, IN) and JOHN D. SCHIERMAN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 929-935. refs
Copyright

This paper investigates the benefits of using Euler angle and rotor angle information in addition to position information in tracking maneuvering helicopters. The tracking problem as addressed here involves estimating present position and predicting the future position of a highly maneuvering target helicopter. The results of a theoretical error variance analysis indicate that trackers using helicopter mathematical models that include translational, fuselage-attitude, and rotor-angle dynamics have lower position, velocity, and acceleration error variances than conventional trackers. Frequency responses of trajectory prediction errors display lower prediction errors for the trackers using attitude and rotor angle information as compared to conventional trackers. Furthermore, simulations have shown that a tracker using attitude and rotor-angle information would null trajectory prediction errors (following a helicopter maneuver) substantially faster than conventional trackers. A large remaining problem for target trackers is the inability to predict accurately future trajectories when the aircraft is undergoing jinking maneuvers. Nonetheless, the use of attitude information in helicopter trackers helps reduce these trajectory prediction errors. Author

A91-19035*# Purdue Univ., West Lafayette, IN.
NAVIGATION PATH PLANNING FOR AUTONOMOUS AIRCRAFT - VORONOI DIAGRAM APPROACH
JIMMY KROZEL and DOMINICK ANDRISANI, II (Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1152-1154. refs
(Contract NCC2-367)
Copyright

The present technique for generating a search graph depicting topologically unique paths around mountain boundaries at constant altitudes involves a description of mountain boundaries as polygons; the search graph is then generated on the basis of a geometric construct. All nodes and arcs of the search graph are guaranteed to lie in free space, thereby ensuring an autonomous aircraft's avoidance of mountain obstacles. The solution path is generated by searching the graph for the optimal path from a start location to a finish location. O.C.

A91-19132#
LOW COST NAVIGATION SYSTEMS FOR UNMANNED AIR VEHICLES
JOHN PATERSON (California Polytechnic University, Pomona) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0091) Copyright

The lightweight, low-cost Unmanned Air Vehicle (UAV) presented requires a relatively inexpensive and lightweight navigation system that can keep the aircraft within a few thousand feet of a predetermined point for eight hours. This paper describes three navigation systems that were modeled in a computer simulation which generated UAV flight paths. The field paths using Automatic Direction Finding (ADF), Global Positioning (GPS), and Distance Measuring Equipment (DME) receivers were simulated using a FORTRAN program. This program simulated the errors inherent in each receiver and compensated for the wind speed and direction. Plots of the flight paths generated under different sets of operating conditions using ADF, GPS and DME receivers were used to evaluate the suitability of these systems. It was determined that, although both the ADF and GPS navigation system could be used, the GPS system was the best choice. Author

N91-13428*# Ohio State Univ., Columbus. ElectroScience Lab.
MODELLING AND PERFORMANCE ANALYSIS OF FOUR AND EIGHT ELEMENT TCAS Semiannual Report, Sep. 1989 - Mar. 1990
K. S. SAMPATH, R. G. ROJAS, and W. D. BURNSIDE Apr. 1990 86 p
(Contract NSG-1498)

(NASA-CR-187414; NAS 1.26:187414; ESL-TR-716199-15)
Avail: NTIS HC/MF A05 CSCL 17/7

This semi-annual report describes the work performed during the period September 1989 through March 1990. The first section presents a description of the effect of the engines of the Boeing 737-200 on the performance of a bottom mounted eight-element traffic alert and collision avoidance system (TCAS). The second section deals exclusively with a four element TCAS antenna. The model obtained to simulate the four element TCAS and new algorithms developed for studying its performance are described. The effect of location on its performance when mounted on top of a Boeing 737-200 operating at 1060 MHz is discussed. It was found that the four element TCAS generally does not perform as well as the eight element TCAS III. Author

N91-13431 Institute for Perception RVO-TNO, Soesterberg (Netherlands).
THE EFFECT OF STEREOSCOPIC PRESENTATION ON A SIMULATED AIR TRAFFIC CONTROL TASK Final Report
J. WALRAVEN and A. D. HEKSTRA 1 Dec. 1989 25 p Original contains color illustrations Contains 3-D glasses as supplement
(IZF-1989-53; TD-89-4551; ETN-91-98304) Copyright Avail: Institute for Perception RVO-TNO, P.O. Box 23, 3769 ZG Soesterberg, Netherlands

Collision prediction in a simulated Air Traffic Control (ATC) task is compared for conditions in which the aircraft displacements on the radar display are shown in either two or three dimensions. The image separation required for stereoscopic (three-dimensional) viewing is achieved by both anaglyphic presentation (red-green glasses) and sequential field stereoscopy (electro-optical shutters). The stimuli consist of traffic scenarios that change in density and complexity. One of the aircraft is singled out to represent the one to be under control. The observer's task is to judge whether it was on a collision course or not. In the two-dimensional condition, the (necessary) altitude information is provided in numerical form. In the three-dimensional condition, experiments both with and without numerical information are performed. The results indicate that stereoscopic information by itself, that is, without numerical altitude information, may already be sufficient for the task under consideration. However, in the condition with combined stereoscopic and numerical altitude information, the performance is not significantly better than in the two-dimensional condition employing numerical information only. Nevertheless, subjects preferred the stereoscopic display over the (normal) two-dimensional format. ESA

N91-14318# Federal Aviation Administration, Atlantic City, NJ.
USING SIMULATION TO EVALUATE THE SAFETY OF PROPOSED ATC OPERATIONS AND PROCEDURES
LEE E. PAUL Oct. 1990 26 p
(Contract FAA-F2006-D)
(DOT/FAA/CT-TN90/22) Avail: NTIS HC/MF A03

Some problems are considered that arise when simulation is used to evaluate capacity enhancing system changes that may also affect safety. A safety standard is proposed that is not based on meeting a predetermined or absolute criterion, but on the ability to demonstrate that the proposed system is as safe as the present one assuming the present system is considered safe. Conversely, a change intended to increase safety would be required to show significantly safe operations vis-a-vis the present standard and, perhaps, no loss of capacity. Author

N91-14320# MiTech, Inc., Washington, DC.
AUTOMATIC DEPENDENT SURVEILLANCE BENEFIT AND COST ANALYSIS Interim Report
G. J. COULURIS Nov. 1990 74 p
(Contract DTFA01-88-Y-D-01025)
(DOT/FAA/RD-90/34; IAT-ADS-BC-1) Avail: NTIS HC/MF A04

A benefit and cost analysis of the economic and operational impacts of automatic dependent surveillance (ADS) is given. The ADS function is currently under development and is designed to use satellite communications and advanced air traffic control (ATC) automation to improve air traffic services in oceanic and other airspaces. ADS will provide direct communication between pilots and air traffic controllers and enhanced ATC flight monitoring and airspace management capabilities. The study identifies the operational benefits and implementation requirements of ADS and analyzes their potential impacts on users and providers of air traffic services. Potential safety benefits are qualitatively assessed. Potential cost savings due to ADS operations are quantitatively estimated as are ADS system implementation costs. The expenditures considered in the analysis include user flight operating costs, air-ground communication user costs, aircraft ADS communication equipage costs, and ATC system enhancement costs. The study examines ADS implementation and potential operational impacts for the North Atlantic and Pacific oceanic areas. The resulting estimated cost savings due to ADS exceed the estimated implementation costs. Author

N91-14322*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT DATA ACQUISITION METHODOLOGY FOR VALIDATION OF PASSIVE RANGING ALGORITHMS FOR OBSTACLE AVOIDANCE
PHILLIP N. SMITH Oct. 1990 17 p Presented at the 46th Annual Forum and Technology Display of the American Helicopter Society, Washington, DC, 21-23 May 1990
(NASA-TM-102809; A-90124; NAS 1.15:102809) Avail: NTIS HC/MF A03 CSCL 01/4

The automation of low-altitude rotorcraft flight depends on the ability to detect, locate, and navigate around obstacles lying in the rotorcraft's intended flightpath. Computer vision techniques provide a passive method of obstacle detection and range estimation, for obstacle avoidance. Several algorithms based on computer vision methods have been developed for this purpose using laboratory data; however, further development and validation of candidate algorithms require data collected from rotorcraft flight. A data base containing low-altitude imagery augmented with the rotorcraft and sensor parameters required for passive range estimation is not readily available. Here, the emphasis is on the methodology used to develop such a data base from flight-test data consisting of imagery, rotorcraft and sensor parameters, and ground-truth range measurements. As part of the data preparation, a technique for obtaining the sensor calibration parameters is described. The data base will enable the further development of algorithms for computer vision-based obstacle detection and passive range estimation, as well as provide a benchmark for verification of range estimates against ground-truth measurements. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-17101
MODELING OF THE COMBINED OPERATION OF THE HELICOPTER ROTOR AND FUSELAGE [MODELIROVANIE SOVMESTNOI RABOTY NESUSHCHEGO VINTA I FIUZELIAZHA VERTOLETA]
E. D. KOVALEV and V. I. MIRGOROD Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 3-10. In Russian.
Copyright

The aerodynamic characteristics of a helicopter rotor are investigated analytically with allowance for the effects of rotor-fuselage interference. A mathematical model based on the discrete vortex method is proposed which makes it possible to determine the integral and distributed aerodynamic characteristics of a helicopter at stationary and transient regimes and to investigate

flow fields in the vicinity of the rotor and the fuselage. The nonlinear nonstationary aerodynamic characteristics of a two-blade rotor are calculated as an example. V.L.

A91-17110
EQUATIONS OF MOTION OF A TOWED BODY - CHARACTERISTICS OF THE NUMERICAL SOLUTION ALGORITHM [URAVNENIIA DVIZHENIIA BUKSIRUEMOGO APPARATA - OSOBENNOSTI ALGORITMA CHISLENNOGO RESHENIIA]
E. P. VACHASOV Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 43-49. In Russian.
Copyright
A refined mathematical model is proposed for the problem of the motion of a body towed by a helicopter. The model is based on the following assumptions: (1) the tow rope is weightless, unstretchable, has no aerodynamic drag, and has a variable length; (2) the point of attachment of the tow rope to the towed body does not coincide with the body's center of gravity; and (3) the effect of the air jet from the rotor is not taken into account. The equations of motion of the towed body are derived from the well-known theorems on momentum and kinetic moment. V.L.

A91-17204
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF DYNAMIC STALL EFFECTS ON ISOLATED ROTOR FLAP-LAG STABILITY
GOPAL H. GAONKAR (Florida Atlantic University, Boca Raton), ROBERT A. ORMISTON (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and DINESH BARWEY IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 39-53. refs
(Contract DAAL03-87-K-0037)
Copyright
An experimental and analytical investigation is conducted of the effects of dynamic stall lift and drag on the flap-lag stability of a hingeless rotor, emphasizing correlations with the measured regressing lead-lag mode damping levels of a soft-inplane, three-bladed model rotor that is operating in the untrimmed mode. The correlations encompass test conditions defined by the values of the rotor speed, collective pitch angle, shaft tilt angle, advance ratio, and flap-lag structural coupling ratio. Both the experimental and analytical blade models represent a simple model of a hingeless, rigid blade with spring-restrained flap-lag hinges. O.C.

A91-17205* Maryland Univ., College Park.
DEVELOPMENT OF UMARC (UNIVERSITY OF MARYLAND ADVANCED ROTORCRAFT CODE)
GUNJIT BIR, INDERJIT CHOPRA (Maryland, University, College Park), and KHANH NGUYEN (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 55-78. refs
(Contract NAG2-409)
Copyright
The University of Maryland Advanced Rotorcraft Code (UMARC) is a user-friendly, FEM-based comprehensive helicopter rotor simulation code of high numerical robustness and computational efficiency. UMARC formulates the rotor-fuselage equations using Hamilton's principle, and are discretized using finite elements in space and time. The FEM formulation allows the code to analyze a wide variety of rotor designs. Dynamic inflow modeling is used for unsteady wake inflow computations. Predicted stability, response, and blade-load data are validated with experimental data for several configurations, including representative articulated, hingeless, and bearingless rotors. O.C.

A91-17207
FREQUENCY-RESPONSE METHOD FOR ROTORCRAFT SYSTEM IDENTIFICATION WITH APPLICATIONS TO THE BO-105 HELICOPTER
MARK B. TISCHLER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and MAVIS G. CAUFFMAN (Sterling Federal Systems, Inc., Palo Alto, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 99-137. refs
Copyright
The present, comprehensive frequency-response method for rotorcraft system identification extracts a complete set of nonparametric input/output frequency responses which characterizes coupled helicopter dynamics, while conducting a search for a state-space model matching the frequency-response data set. By subsequently combining the results of multiinput frequency-response analyses obtained from a range of spectral windows into a single optimized response, the manual optimization of windows is obviated. A nine-degree-of-freedom hybrid model which encompasses coupled body/rotor flapping and lead-lag dynamics, and is accurate to 30 rad/sec, is applied to flight control design; it is found that the maximum roll rate gain is limited by the destabilization of the lead-lag dynamics. O.C.

A91-17208* McDonnell-Douglas Helicopter Co., Mesa, AZ.
FINITE ELEMENT MODEL REDUCTION APPLICATION TO PARAMETRIC STUDIES AND OPTIMIZATION OF ROTORCRAFT STRUCTURES
M. HASHEMI-KIA and M. TOOSSI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 139-154. refs
(Contract NAS1-17498)
Copyright
As a result of this work, a reduction procedure has been developed which can be applied to large finite element model of airframe type structures. This procedure, which is tailored to be used with MSC/NASTRAN finite element code, is applied to the full airframe dynamic finite element model of AH-64A Attack Helicopter. The applicability of the resulting reduced model to parametric and optimization studies is examined. Through application of the design sensitivity analysis, the viability and efficiency of this reduction technique has been demonstrated in a vibration reduction study. Author

A91-17209 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PRELIMINARY ASSESSMENT OF A SUPERSONIC STOVL FLIGHT RESEARCH AND DEMONSTRATION AIRCRAFT
JEFFREY J. SAMUELS (NASA, Ames Research Center, Moffett Field, CA) and GORDON A. PAYNE (NASA, Flight Research Center, Edwards, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 157-164. refs
Copyright
NASA Ames has conducted a conceptual design study of a supersonic short takeoff and vertical landing (STOVL) flight research and demonstration aircraft sized according to current technology levels. The aircraft would provide the capability for demonstrating advanced technologies required for STOVL and would be instrumented to provide temperature, pressure, and noise data for power-induced-effects research. The propulsion concept for the single-engine aircraft studied operates in mixed flow without thrust augmentation during power-lift flight. The study aircraft is full scale to facilitate STOVL propulsion-system component validation and power-induced aerodynamics research. Performance is sufficient to permit investigation and validation of vertical landing and hover, accelerating and decelerating transitions, short takeoff, reduced-weight vertical takeoff, and supersonic flight. Mission and maneuver capability is sufficient to demonstrate the operational utility of this class of aircraft. Aircraft mission and technology sensitivities were also examined. Author

A91-17211
VSTOL CONCEPTS FOR SPECIAL OPERATIONS
AL DISSELKOEN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: AHS, Annual Forum,

46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1 (A91-17201 05-01). Alexandria, VA, American Helicopter Society, 1990, p. 183-192.
Copyright

Over the last ten years the awareness of Special Operations missions has significantly increased. Events such as the failed hostage rescue in Iran have also highlighted the need to develop an aircraft with the capability to penetrate unfriendly territory in a clandestine manner and to infiltrate/exfiltrate/resupply Special Operations Forces (SOF) at an unprepared site. This requires long range with vertical operations, a combination satisfied by neither a conventional transport or helicopter. This need has prompted several Air Force in-house and contracted aircraft studies. A summary of the requirements and a systems engineering overview of a 1989 study of potential VSTOL vehicle concepts are discussed. Also, significant technology development is needed for this demanding mission despite the demonstration of several VSTOL concepts in the past. Author

A91-17212
TRAIL ROTOR V/STOL AIRCRAFT, FEATURES AND APPLICATIONS
K. W. SAMBELL, D. S. JANAKIRAM, and L. J. SILVERTHORN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 193-210. refs
Copyright

The Trail Rotor Convertiplane (TRC) has potential for many V/STOL military missions requiring medium disk loadings of 15 to 30 pounds per square foot and high cruise speeds. The twin-rotor configuration has a maximum speed potential to 500 knots and the single-rotor configuration to 1000 kts (Mach 1.5). Stopping a rotor in-flight has long been an industry goal and the soft-inplane rotor with an active rotor-stabilization system is being investigated. The paradox of the TRC is that while the aft-conversion is unusual, the aft autorotation contributes to pylon-wing stability during conversion, and the airplane cruise configuration has an attractive cruise lift/drag (L/D). This paper discusses features and applications of the concept, including the aerodynamic and aeroelastic challenges of the rotors and wing. Author

A91-17227
VALIDATION OF A NEW GENERAL AEROSPATIALE AEROELASTIC ROTOR MODEL THROUGH THE WIND TUNNEL AND FLIGHT TESTS DATA
M. ALLONGUE and T. KRYSINSKI (Aerospatiale, Division Helicopteres, Marignane, France) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 389-402. refs
Copyright

The present numerical method for use in performance, loads, vibration, and stability studies of helicopter rotors is distinguished by fast execution time, interactivity, and easy application in parametric studies. Articulated, hingeless, bearingless, teetering, interblade-damped, pendulum absorber-equipped, and variously blade-shaped rorots can be represented. The validation of these analyses is conducted on the basis of flight test measurements and rotor wind-tunnel tests. Both a rigid blade model and a flexible blade model derived from the rigid case are treated. An application of these models to the Super Puma Mk2 prototype emphasizes the need for a full application of rotor-fuselage coupling in order to represent hub impedance. O.C.

A91-17228
A MODAL-BASED PROCEDURE FOR EFFICIENTLY PREDICTING LOW VIBRATION ROTOR DESIGNS
WILLIAM H. WELLER and MARK W. DAVIS (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 403-416. refs
Copyright

The analytical method presently developed for predicting helicopter-blade structural properties resulting in low vibratory response encompasses (1) the incorporation of modal-based low-vibration design criteria into a design optimization analysis, (2) the evaluation of alternative optimization algorithms and problem formulations for vibration-oriented design optimization studies, (3) wind tunnel test verifications of the consequent designs, and (4) a comparison of measured and predicted dynamic characteristics for baseline and optimized rotor designs, in order to ascertain the associations between structural design variations and vibrational characteristics. Attention is given to the results obtained by the fourth part of this method. O.C.

A91-17229
APPLICATION OF NONLINEAR PROGRAMMING TECHNIQUES TO DYNAMIC CORRELATION AND DESIGN OF HELICOPTER STRUCTURES
T. L. C. CHEN, S. PIZZOLATO, and W. J. TWOMEY (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 417-427. refs
Copyright

A significant improvement has been obtained in analysis/test result correlation as a result of the incorporation of the PAREDYM FEM model of a shake-test suspension system with the model of a UH-60A helicopter airframe. PAREDYM has helped to reduce vibration at the blade-passage frequency by not only moving the natural frequencies away from it, but adding mode-shape alteration. Application of PAREDYM without constraints resulted in a 67-percent reduction in pilot response; application with weight-change and stiffness constraints, in order to obtain realistic structural design change calculation results, yielded a vibration reduction of 39 percent. O.C.

A91-17231
HINGELESS ROTOR BLADE STABILITY USING A COUPLED AEROELASTIC ANALYSIS WITH REFINED AERODYNAMIC MODELING
MICHAEL S. TOROK and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 447-458. refs
(Contract DAAL03-88-C-0002)
Copyright

A nonlinear unsteady aerodynamic model based on an indicial methodology is incorporated into a comprehensive coupled rotor aeroelastic analysis to investigate hingeless rotor blade stability. The aerodynamic analysis consists of three phases, a nonlinear separated flow solution, a nonlinear dynamic stall solution, and a linear attached flow solution. It is concluded that, at high advance ratios, the inclusion of nonlinear unsteady aerodynamics is of importance in predicting lag damping characteristics. Results utilizing a free wake analysis show its importance in the determination of rotor trim, which in turn affects lag damping predictions. R.E.P.

A91-17232* Analytical Services and Materials, Inc., Hampton, VA.
AN ENHANCED INTEGRATED AERODYNAMIC LOAD/DYNAMIC APPROACH TO OPTIMUM ROTOR BLADE DESIGN
ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA) and Y. DANNY CHIU (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 459-468. Previously announced in STAR as N90-29383. refs
(Contract NAS1-18599; NAS1-18000)
Copyright

An enhanced integrated aerodynamic load/dynamic

optimization procedure is developed to minimize vibratory root shears and moments. The optimization is formulated with 4/rev vertical and 3/rev inplane shears at the blade root as objective functions and constraints, and 4/rev lagging moment. Constraints are also imposed on blade natural frequencies, weight, autorotational inertia, contrifugal stress, and rotor thrust. The Global Criteria Approach is used for formulating the multi-objective optimization. Design variables include spanwise distributions of bending stiffnesses, torsional stiffness, nonstructural mass, chord, radius of gyration, and blade taper ratio. The program CAMRAD is coupled with an optimizer, which consists of the program CONMIN and an approximate analysis, to obtain optimum designs. The optimization procedure is applied to an advanced rotor as a reference design. Optimum blade designs, obtained with and without a constraint on the rotor thrust, are presented and are compared to the reference blade. Substantial reductions are obtained in the vibratory root forces and moments. As a byproduct, improvements are also found in some performance parameters, such as total power required, which were not considered during optimization. Author

A91-17233* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATUS OF INTEGRATED MULTIDISCIPLINARY ROTORCRAFT OPTIMIZATION RESEARCH AT THE LANGLEY RESEARCH CENTER
WAYNE R. MANTAY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) and HOWARD M. ADELMAN (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 471-481. refs

This paper describes a joint NASA/Army research activity at the Langley Research Center to develop optimization procedures aimed at improving the rotor blade design process by integrating appropriate disciplines and accounting for important interactions among the disciplines. The activity is being guided by a Steering Committee made up of key NASA and Army researchers and managers. The paper describes the optimization formulation in terms of the objective function, design variables, and constraints. The analysis aspects are discussed, and the interdisciplinary interactions are defined in terms of the information that must be transferred among disciplinary analyses as well as the trade-offs between disciplines in determining the details of the design. At this writing, some significant progress has been made. Results given in the paper represent accomplishments in rotor aerodynamic performance optimization for minimum horsepower, rotor dynamic optimization for vibration reduction, approximate analysis of frequencies and mode shapes, rotor structural optimization for minimum weight, and integrated aerodynamic load/dynamics optimization for minimum vibration and weight. Author

A91-17234
MBB'S BO 108 DESIGN AND DEVELOPMENT
HELMUT B. HUBER and CLAUS SCHICK (MBB GmbH, Munich, Federal Republic of Germany) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 483-496. Previously announced in STAR as N91-10055. refs

The development by MBB of a new light twin, multipurpose helicopter, designated as the BO-108 is described. The design requirements and the technology advances in terms of the various components involved (rotor systems, drive system, anti-vibration system, control system, airframe, cockpit and cabin) are presented. An overview on the current status of bench and in-flight testing is given and the progress achieved in the fields of performance, flying qualities, noise and vibrations, weight, reliability and safety is assessed. Studies for increasing the aircraft's capabilities are described and a prospective about the future program plans is given. Author

A91-17235
THE FRANCO-GERMAN TIGER PROGRAM - A DEVELOPMENT STATUS
KLAUS SCHYMANIETZ (MBB GmbH, Munich, Federal Republic of Germany) and MANUEL TORRES (Aerospatiale, Marignane, France) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 497-508.

MBB and Aerospatiale are developing a common basic helicopter which will utilize different mission equipment for a combat support version that includes ground support and air-to-air capabilities, and an antitank version. Advanced technological innovations will embody a main rotor with composite hub, elastomeric bearings and composite blades, an all-composite fuselage, and roof/mast mounted sights with IR, TV and optics channels, and laser telemetry. Some details are provided on vehicle subsystems including rotors, drive system and fuselage. Avionics are then described with particular attention given to man-machine interface. R.E.P.

A91-17237
ADVANCED CARGO AIRCRAFT SIZE OPTIMIZATION
CHRISTOPHER P. VAN BUITEN (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 523-533.

A knowledge-based simulation was developed and exercised to determine optimum vehicle sizes for the Army's next generation cargo helicopter, the Advanced Cargo Aircraft (ACA). Upon review of 264 different aircraft sizes, optimum combinations of cabin dimensions and payload lift capability were determined for single and tandem rotor helicopter configurations. Optimum vehicle sizes were selected based on productivity and mission effectiveness parameters, and preliminary designs were developed to assess costs and to identify technology issues. An aircraft with a 26,000 pound payload capacity in 'hot and high' conditions, 270 nautical mile radius of action, and a 35 x 9 x 9 foot cabin was determined to be optimum. Author

A91-17238
TAILBOOM DESIGN OF THE 520N NOTAR HELICOPTER
CARLO S. RAO (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 549-556.

The use of advanced composite materials allows for innovative design solutions to the unique challenges associated with production of circulation control tailbooms. It also provides an effective means for optimization of the weight and performance of the structure, one of the primary goals of McDonnell Douglas Helicopter Company's 520N NOTAR helicopter project. This paper shows how the unique technical challenges were confronted during the development of MDHC's 520N NOTAR tailboom. It then presents the way in which these challenges were met by utilizing some of the inherent advantages of a 'composite' design. Tests that validated various aspects of the design are then reviewed as are the results. Author

A91-17248
HELICOPTER CREW STATION DESIGN USING A COMPUTERIZED HUMAN MODEL
A. O. BOLUKBASI and C. M. BERTONE (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 649-654. refs

A computerized modeling system, Program MACMAN (McDonnell Anthropometric Computerized Man-Model), has been developed to assist in designing helicopter crew stations. MACMAN

combines a three-dimensional representation of the human body with the crew station geometry. The human body model consists of twelve segments whose dimensions and kinematic constraints have been determined from studies of human anthropometry. MACMAN is menu-driven and very user-friendly. The human model sizes can be interactively changed to represent 5th percentile female through 95th percentile male crew members. The human model can also be animated to evaluate reach envelopes and collision and interaction detection. MACMAN has been validated and used in design of the MD900 crew station, dramatically reducing the time needed to construct mockups and design iterations. Author

A91-17254
STATIC TESTING OF V-22 AIRFRAME STRUCTURE
WILLIAM J. KESACK and GARY N. BACHMAN (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 695-701.
Copyright

The V-22 Static Test Program is used to structurally qualify and demonstrate the integrity of the airframe structure for critical conditions. This is accomplished through tests on the Static Test Article (STA), nacelle and components. Test cases were selected to match critical conditions and aircraft shear and moment envelopes. Loads are applied through straps, lugs, clamps and pads. The Load Control System (LCS) is a computer controlled servo hydraulic system with multiple safety features to prevent excessive loads. Data Acquisition System (DAS) computers have 1624 channels available to monitor loads, strains and displacements during testing. Predictions from a NASTRAN model, measured test data, and design values are compared during and after each test condition. The V-22 Static Test Program permits the V-22 Flight Test envelope to be fully expanded. Author

A91-17261* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODEL TILT-ROTOR HOVER PERFORMANCE AND SURFACE PRESSURE MEASUREMENT
CHEE TUNG and LONNIE BRANUM (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 785-796. Previously announced in STAR as N90-26827. refs
Copyright

A test of a small scale 3-bladed model rotor, with geometry typical of that used on tilt rotor aircraft, was conducted in the Army Aeroflightdynamics Directorate's anechoic hover chamber. The purpose was to determine the hover performance of the rotor and investigate the pressure distributions on a blade at various collective pitch angles and tip speeds. The measured pressures indicate that the rotor did not stall for high collective pitch angles up to theta sub c = 25 deg. This is clearly a 3-D effect since 2-D theory predicts flow separation at these high angles. The flow near the trailing edge separated above theta sub c = 25 deg which caused a sharp increase in power. Author

A91-17266
DAMAGE TOLERANCE TESTING OF SH-2 SEASPRITE COMPOSITE MAIN ROTOR BLADE
K. DRAKE KLOTZMAN and FRANK B. CLARK (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 833-839.
Copyright

Structural performance of composite components can be affected by the presence of inherent or latent manufacturing anomalies. In order to fully evaluate the impact of these flaws and their associated failure modes in an all composite rotor blade, Kaman Aerospace developed a full scale damage tolerance fatigue test. This paper discusses the steps required to develop this test, including load derivation and specimen preparation, the philosophy of the test, and the application of the results to quality acceptance criteria. Author

A91-17268
SAFE STRENGTH/DAMAGE TOLERANCE ASSESSMENT VS A FAIL-SAFE APPROACH IN THE DESIGN OF THE SH-2G ENGINE MOUNT STRUCTURE
CHARLES D. VAN ETTEN and PAUL E. KEARY (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 851-858. refs
Copyright

A safe strength/damage tolerance analysis of the model SH-2G helicopter engine mount structure was undertaken in order to avoid the weight penalty and structural/maintenance complexities of a fail-safe design. The conservative nature of the safe strength assessment methodology resulted in reduction of the specification required tests while adding less than ten percent of the structural weight that would have been required by the fail-safe approach. This paper describes the structural arrangement of the two designs (safe strength and fail-safe) and the analytical process used to assess the safe strength/damage tolerance approach. Author

A91-17271
A NEW METHODOLOGY TO PREDICT AND OPTIMIZE ROTORCRAFT STRUCTURAL LOADS/WEIGHTS USING FINITE ELEMENT METHOD
SOHAN SINGH and DAVID R. LINDSAY (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 885-896. Research supported by Bell Helicopter Textron Independent Research and Development Funds.
Copyright

An automated loads/weights optimization procedure is developed which will allow rapid prediction of initial sizes, weights, internal loads, and structural material weight fractions at an early stage of helicopter design definition. Rotorcraft weights are generated on the basis of empirical and semiempirical weight-prediction equations. Airframe structural weight is optimized on the basis of fully stressed design criteria; the weights represented by fasteners, splices, honeycomb panels, surface coatings, and fittings, are computed on the basis of historical data and added to the optimized structural weight to arrive at greater realism. O.C.

A91-17287
V-22 FLIGHT TEST - A PROMISE FULFILLED
MICHAEL A. MCVEIGH and HAROLD ROSENSTEIN (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1065-1073.
Copyright

The tiltrotor concept is compared to other forms of V/STOL aircraft and its high hover efficiency and cruise efficiency is shown to combine to maximize productivity for both short- and long-range missions. Initial developmental flight testing of the V-22 Osprey is reviewed and shows that the aircraft will meet its goals. Author

A91-17295
DESIGN AND TEST OF AN ADVANCED TECHNOLOGY LANDING GEAR
JOYANTO K. SEN (McDonnell Douglas Helicopter Co., Mesa, AZ) and NED A. CHASE (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1175-1186. (Contract DAAJ02-85-C-0049)
Copyright

A retractable, crashworthy main landing gear for a utility helicopter was designed, fabricated and tested to the crashworthiness requirements of a vertical velocity of 42 fps, at

+ or - 10 deg roll and -5 deg/+15 deg pitch. The landing gear is very compact and highly maintainable, and automatically extends in less than two seconds in an emergency. Through energy absorbing trade-off studies and crashworthiness analyses, the gear was optimized to absorb 60 percent of the energy from a level impact at 42 fps; the remaining energy was absorbed by the fuselage and the stroking seat. The landing gear was evaluated through single-gear platform and iron-bird drop tests. The test results identified differences in the behavior of the gear in the two types of tests. Author

A91-17296
ENDURANCE TESTING OF DAMAGED MAIN ROTOR UPPER THRUST BEARINGS
MICHAEL C. FRENGLEY and JERRY D. EAKIN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1187-1206.

A test designed to establish safe increments for increases in the overhaul life of the bearing and to determine the interval between the onset of damage and the final failure of the bearing is conducted. The test involved the deliberate spalling of two upper hub bearings, followed by the testing of these bearings back to back under typical flight loads. Information is provided on growth of spalls, grease samples, and bearings test history. It is concluded that the upper thrust bearing of the AH-64A 'Appache' attack helicopter can be operated safely for at least 500 hours after the initiation of a spall. Also, it is suggested that the bearing condition is quite detectable and that properly installed rolling element bearings can be retired on condition, rather than at a predetermined safe life. L.K.S.

A91-17307* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A COMPARISON OF REAL-TIME BLADE-ELEMENT AND ROTOR-MAP HELICOPTER SIMULATIONS USING PARALLEL PROCESSING
LLOYD CORLISS (NASA, Ames Research Center, Moffett Field, CA), RONALD W. DU VAL, HERBERT GILLMAN, III, and LOC C. HUYNH (Advanced Rotorcraft Technology, Inc., Mountain View, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1327-1354. refs

In recent efforts by NASA, the Army, and Advanced Rotorcraft Technology, Inc. (ART), the application of parallel processing techniques to real-time simulation have been studied. Traditionally, real-time helicopter simulations have omitted the modeling of high-frequency phenomena in order to achieve real-time operation on affordable computers. Parallel processing technology can now provide the means for significantly improving the fidelity of real-time simulation, and one specific area for improvement is the modeling of rotor dynamics. This paper focuses on the results of a piloted simulation in which a traditional rotor-map mathematical model was compared with a more sophisticated blade-element mathematical model that had been implemented using parallel processing hardware and software technology. Author

A91-17308
NATC MANNED FLIGHT SIMULATOR VTOL SHIP MOTION SIMULATION AND APPLICATION
BERNARD FERRIER (Bombardier, Inc., Canadair Div., Montreal, Canada) and JEFFREY SEMENZA (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1355-1372. refs

A brief synopsis of the theory, background and calculations of the ship motion simulation program using the O'Reilly method is presented. The evolution of time histories from seaway/ship spectral densities are discussed. The application of ship dynamics in the NATC Manned Flight Simulator is presented. Dynamic interface (DI) development is composed of two approaches, experimental and analytic. The primary thrust of USN DI is experimental. A cooperative program between the U.S. and Canada created the means for the development of advanced shipmotion models. Alongside the experimental approach, the analytic strives to assist in the definition of safe operational conditions aboard ships or marine platforms. The O'Reilly shipmotion models define the landing platform in space and time; defines safe air vehicle/platform deck handling envelopes; determines system effectiveness in degraded modes; and, stimulates other related applications or extensions, such as, a landing period designator. Author

A91-17639#
BELL'S DESIGN APPROACH FOR FUTURE ROTORCRAFT MAINTENANCE/DIAGNOSTICS
H. FRANKS, R. SAMSON, R. PATTEN, and J. EMERY (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 9 p.

Programs addressing the development of advanced rotorcraft maintenance/diagnostics technology guidelines and their application in the engineering design process are overviewed. Programs focusing on solving specific aircraft diagnostics-related problems are covered, along with programs addressing onboard maintenance/diagnostics aids including health, usage/lifing, monitoring systems for commercial helicopters, and health-monitoring systems on rotorcraft. The Generic Integrated Maintenance and Diagnostics System (GIMADS) is discussed, with focus placed on the mechanical-system diagnostics portion of the specification development. Attention is drawn to advanced maintenance/diagnostics requirements and the development of guidelines for incorporating maintenance/diagnostics into advanced avionics architecture. V.T.

A91-17648*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VALIDATION OF THE DYNAMIC RESPONSE OF A BLADE-ELEMENT UH-60 SIMULATION MODEL IN HOVERING FLIGHT
MARK G. BALIN (NASA, Ames Research Center, Moffett Field, CA) and MARIE-ALIX DALANG-SECRETAN (Sterling Software, Inc., Palo Alto, CA) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 36 p. refs

The dynamic fidelity of an operational blade-element simulation model of the UH-60 helicopter is assessed for the hovering and low-speed flight regimes. Nonparametric frequency-domain identification techniques and time-history comparisons are used to determine the validity of total-vehicle on-axis and coupled responses. A dedicated flight-test program was conducted to provide data used in the analysis. The flight-test techniques and data verification methods employed are briefly described. Frequency-domain methods are applied to the model and to several model components in order to isolate deficiencies and verify refinements and corrections. Model deficiencies are also identified by using side-by-side pilot assessments of a motion-base simulation and of a test aircraft. Model updates are found to significantly improve fidelity in the frequency range that is of interest to handling-qualities research. The applicability of the model to high-bandwidth flight-control research is also discussed. Author

A91-17649#
HELICOPTER DESIGN SUPPORT TESTING IN THE MCDONNELL DOUGLAS RESEARCH LABORATORIES HOVER RESEARCH FACILITY
JAMES H. EKINS, ROGER L. SMITH (McDonnell Douglas Helicopter Co., Mesa, AZ), and KONDALA R. SARIPALLI (McDonnel Douglas Research Laboratories, Saint Louis, MO) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 9 p.

A 7-percent scale model of a future light helicopter was tested using flow visualization techniques in the MDRL Hover Research

Facility, which uses water as the working medium. The primary test objective was to investigate the effects of engine nacelle configuration and engine exhaust pipe angle on no-tail-rotor ('Notar') boom performance in hover. A second objective was to determine, for this particular airframe design, whether engine exhaust would be ingested by the Notar fan inlet. Flow visualization was achieved by illuminating the desired cross-section of the flow with an argon-ion laser light sheet, with either light-reflecting particles or fluorescent dye to trace the flow fields. Three engine nacelle configurations were tested, one of which was found to be unsuitable due to its disruption of flow attachment on the Notar boom. The flow visualization showed that Notar boom performance was not affected by engine exhaust pipe angle, and that the Notar fan inlet will experience no ingestion of engine exhaust. Author

A91-17650#
PROGRAM AND OPERATIONAL HIGHLIGHTS OF THE ARMED OH-58D KIOWA WARRIOR
MYRON MICHAEL KAWA (Bell Helicopter Textron, Inc., Fort Worth, TX) and JACK M. VAN KIRK (U.S. Army, Program Executive Office, Washington, DC) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 84 p. refs

The reequipping of 15 Army OH-58D aerial observation aircraft by members of a military and civilian Operation Prime Chance team in order to provide the night scout aircraft with fully armed capability is discussed. The testing, development of operational procedures, training of crews, and rapid deployment to overseas locale is detailed. The integration of weapons systems into the modern, user-friendly OH-58D cockpit controls and displays is elaborated. Planned qualifications tests and schedules are also described. The Multi-Purpose Light Helicopter (MPLH) development concept is also described in detail. It is pointed out that, in the MPLH configuration, the armed OH-58D is capable of many different missions, including rapid air deployment aboard military transport aircraft. Armed operational aspects describing performance at the National Training Center, REFORGER exercises, and armed fielding are discussed. L.K.S.

A91-17992
FREQUENCY-SWEPT ROTATING INPUT PERTURBATION TECHNIQUES AND IDENTIFICATION OF THE FLUID FORCE MODELS IN ROTOR/BEARING/SEAL SYSTEMS AND FLUID HANDLING MACHINES
A. MUSZYNSKA and D. E. BENTLY (Bently Rotor Dynamics Research Corp., Minden, NV) Journal of Sound and Vibration (ISSN 0022-460X), vol. 143, Nov. 22, 1990, p. 103-124. refs
Copyright

Perturbation techniques used for identification of rotating system dynamic characteristics are described. A comparison between two periodic frequency-swept perturbation methods applied in identification of fluid forces of rotating machines is presented. The description of the fluid force model identified by inputting circular periodic frequency-swept force is given. This model is based on the existence and strength of the circumferential flow, most often generated by the shaft rotation. The application of the fluid force model in rotor dynamic analysis is presented. It is shown that the rotor stability is an entire rotating system property. Some areas for further research are discussed. Author

A91-18075
FLYING THE FIRST TEAM'S FANTAIL-EQUIPPED H-76
DAVID S. HARVEY Rotor and Wing International (ISSN 0191-6408), vol. 24, Dec. 1990, p. 42-44.
Copyright

A performance evaluation has been conducted, using a retrofitted H-76 helicopter, of the 'Fantail' helicopter tailrotor concept chosen by one of the competing design teams of a manufacturer involved in the development program for the U.S. Army's LH attack/utility helicopter program. The primary alternative to the 'Fantail' tail rotor is the 'Notar', no-tail-rotor thrust-vectoring concept. One of the Army performance requirements addressed by these flight tests was sufficient tail-rotor authority to turn 180 deg during cross-wind conditions of up to 45 knots. O.C.

A91-18150
ADVANCING THE ATF
GRAHAM WARWICK Flight International (ISSN 0015-3710), vol. 138, Nov. 27, 1990, p. 26-29.
Copyright

Either the YF-22 or the YF-23 will be selected as the Advanced Tactical Fighter of the future in a competitive flyoff to replace current USAF F-15s and USN F-14s. The potential for introducing stealth technology, and advanced aerodynamic and structural improvements beyond the current fighters are the principal factors in favor of the costly development of an all-new ATF. The YF-23 incorporates a trapezoidal wing 55 percent bigger than that of the F-15 while the YF-22's wing is smaller, only 35 percent bigger than the F-15's, and closer to a classical delta in planform. Both YF's will develop about 70,000 lbs/thrust from two engines, giving the ATF a combat takeoff thrust-to-weight ratio of about 1.1/1. For the stealth features, both YFs embody the same fundamental principles, although applied with different emphasis in each case. In regard to weaponry, the ATF will probably require the development of a folding-fin version of a medium range missile for internal carriage. R.E.P.

A91-18252*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF A PATCHED-GRID ALGORITHM TO THE F/A-18 FOREBODY-LEADING-EDGE EXTENSION CONFIGURATION
JAMES L. THOMAS, ROBERT P. WESTON, JAMES M. LUCKRING (NASA, Langley Research Center, Hampton, VA), ROBERT W. WALTERS (Virginia Polytechnic Institute and State University, Blacksburg), TAEKYU REU (Florida State University, Tallahassee), and FARHAD GHAFFARI (Vigyan, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 749-756. Previously cited in issue 09, p. 1291, Accession no. A89-25106. refs
(Contract NAG1-866; NAS1-17919)
Copyright

A91-18253#
FINITE ELEMENT STUDIES OF THE ELECTRO IMPULSE DE-ICING SYSTEM
R. J. SCAVUZZO, M. L. CHU (Akron, University, OH), E. J. WOODS (Boeing Commercial Airplanes, Seattle, WA), A. A. KHATKHATE (Innovative Dynamics, Ithaca, NY), and R. RAJU Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 757-763. Previously cited in issue 18, p. 3000, Accession no. A88-45375. refs
Copyright

A91-18255#
AEROELASTIC STABILITY OF AIRCRAFT WITH CIRCULATION CONTROL WINGS
DAVID J. HAAS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and INDERJIT CHOPRA (Maryland, University, College Park) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 771-778. Previously cited in issue 12, p. 1780, Accession no. A89-30674. refs

A91-18258#
VELOCITY FIELD OF A CYLINDER IN THE WAKE OF A ROTOR IN FORWARD FLIGHT
S. G. LIOU, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 804-809. Previously cited in issue 07, p. 946, Accession no. A88-22496. refs
(Contract DAAG29-82-K-0084)
Copyright

A91-18261#
THERMOVISCOPLASTIC ANALYSIS OF HYPERSONIC STRUCTURES SUBJECTED TO SEVERE AERODYNAMIC HEATING
EARL A. THORNTON, J. TINSLEY ODEN (Texas, University,

Austin), W. WOYTEK TWORZYDLO, and SUNG-KIE YOUN (Computational Mechanics Co., Inc., Austin, TX) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 826-835. Research supported by USAF. Previously cited in issue 12, p. 1781, Accession no. A89-30713. refs
Copyright

A91-18262#
ELEVATED TEMPERATURE ALUMINUM ALLOYS FOR ADVANCED FIGHTER AIRCRAFT
J. C. EKVALL, R. A. RAINEN, D. J. CHELLMAN (Lockheed Aeronautical Systems Co., Burbank, CA), R. R. FLORES (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and M. J. GERSBACH (Lockheed Aeronautical Systems Co., Marietta, GA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 836-843. Previously cited in issue 12, p. 1783, Accession no. A89-30880. refs
Copyright

A91-18364
WIND EFFECTS ON HELICOPTER TAKEOFF AND LANDING
N. TRAENAPP (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Vertica (ISSN 0360-5450), vol. 14, no. 3, 1990, p. 439-454. refs
Copyright
On account of direct influence on the desired flight path during takeoff and landing, wind can give rise to considerable changes in power required, and is thus of significance to flight safety. Some accidents have been found to be caused by wind interference, sometimes combined with some other causes, as for example engine failure. Investigations into normal takeoff and landing procedures according to FAR part 29, category A present the influence of wind on helicopter takeoff and landing and document possible endangering situations. In addition to this, problems of interaction between helicopters in terminal operations and aircraft vortex wakes are discussed. The examinations employ several simulation models of different extension, which are briefly mentioned. Author

A91-18385
DEVELOPMENT OF AN ADVANCED TECHNOLOGY BALLISTIC POWERED INERTIA REEL
BOB LEVAY (Pacific Scientific Co., Yorba Linda, CA) SAFE Journal, vol. 20, Winter 1990, p. 7-10.
Copyright
With the advent of new higher performance aircraft comes the need for higher performance emergency egress in the form of pilot ejection sequences. Prior to the catapult initiation during an ejection there is a need to haulback the pilot to align his spinal column against the seat back. This aids in reducing spinal injuries that can be caused by the extreme acceleration experienced during the catapult event. The spinal column can withstand significant load in compression when it is aligned, but is susceptible to injury during torsional or bending loads. Author

A91-18648
NEW ENGINES, SENSORS, AVIONICS GIVE F-14D BROADER COMBAT ROLE
DAVID M. NORTH (USAF, Patuxent River Naval Air Station, MD) Aviation Week and Space Technology (ISSN 0005-2175), vol. 133, Dec. 17, 1990, p. 36-39.
Copyright
The planned introduction of the F-14D will provide the USN with a fighter that has greatly improved flight characteristics, active as well as passive sensors and better weaponry than its predecessor, the F-14A. It will also incorporate digital avionics, an IR search and track, a new radar and multifunction displays to improve pilot situation awareness. A demonstration flight is described with special emphasis placed on the advanced avionics and digital stores management system for the radar intercept officer who will occupy the rear cockpit. The F-14D has a mechanical flight control system, but a digital system is presently under consideration. While the F-14D is seen as a major step forward in aircraft performance and systems, the Navy has plans to improve it even further with such enhancements as a more powerful engine and advanced medium and long-range air-to-air missiles. R.E.P.

A91-18905*# Old Dominion Univ., Norfolk, VA.
APPLICATION OF LAGRANGIAN BLENDING FUNCTIONS FOR GRID GENERATION AROUND AIRPLANE GEOMETRIES
JAMSHID SAMAREH-ABOLHASSANI, IDEEN SADREHAGHIGHI, SURENDRA N. TIWARI (Old Dominion University, Norfolk, VA), and ROBERT E. SMITH (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 873-877. Previously cited in issue 06, p. 867, Accession no. A90-19630. refs
(Contract NCC1-68)
Copyright

A91-18906#
TRANSONIC COMPUTATIONAL METHOD FOR AN AFT-MOUNTED NACELLE/PYLON WITH POWER EFFECT
L. T. CHEN, K. C. YU, and T. Q. DANG (Douglas Aircraft Co., Long Beach, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 878-885. Previously cited in issue 09, p. 1291, Accession no. A89-25449. refs
Copyright

A91-18908*# Douglas Aircraft Co., Inc., Long Beach, CA.
CABIN NOISE CONTROL GROUND TESTS FOR ULTRA HIGH BYPASS AIRCRAFT
M. A. SIMPSON (Douglas Aircraft Co., Long Beach, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 893-900. Previously cited in issue 13, p. 1943, Accession no. A89-33755.
(Contract NAS1-18037)
Copyright

A91-18909#
AEROELASTIC CHARACTERISTICS OF A HIGHLY FLEXIBLE AIRCRAFT
MARTHINUS C. VAN SCHOOR and ANDREAS H. VON FLOTOW (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 901-908. Previously cited in issue 12, p. 1780, Accession no. A89-30677. refs
Copyright

A91-18917#
ANALYZING ROTOR DYNAMICS WITH A GENERAL-PURPOSE CODE
ANDREW S. ELLIOTT and JAMES B. MCCONVILLE (Mechanical Dynamics, Inc., Ann Arbor, MI) Mechanical Engineering (ISSN 0025-6501), vol. 112, Dec. 1990, p. 21-25.
Copyright
ADAMS, a general analysis code for predicting the dynamic behavior of helicopter rotors, is presented. The code can handle the effects of rotation, unsteady aerodynamics, and geometric nonlinearities that characterize rotor aeromechanics, and it can automatically generate numerical equations of motion. ADAMS is used as a basis for the development of an analytical rotor model capable of rapid maneuvering in flight under full control. The structural model consists of rigid blades attached to a rotating hub and a six-state controller which adjusts the collective and cyclic pitches. Throughout the modeling process, no restrictions are placed on the translational or rotational displacements or velocities at any of the joints. Solutions of equivalent problem using either ADAMS or the standard CAMRAD/JA code based on a periodic response assumption are compared, and the correlations are found to be very good. B.P.

A91-19023*# Massachusetts Inst. of Tech., Cambridge.
ORTHOGONAL SERIES GENERALIZED LIKELIHOOD RATIO TEST FOR FAILURE DETECTION AND ISOLATION
STEVEN R. HALL (MIT, Cambridge, MA) and BRUCE K. WALKER (Cincinnati, University, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1064-1074. refs

(Contract NAS1-17556)
Copyright

A new failure detection and isolation algorithm for linear dynamic systems is presented. This algorithm, the Orthogonal Series Generalized Likelihood Ratio (OSGLR) test, is based on the assumption that the failure modes of interest can be represented by truncated series expansions. This assumption leads to a failure detection algorithm with several desirable properties. Computer simulation results are presented for the detection of the failures of actuators and sensors of a C-130 aircraft. The results show that the OSGLR test generally performs as well as the GLR test in terms of time to detect a failure and is more robust to failure mode uncertainty. However, the OSGLR test is also somewhat more sensitive to modeling errors than the GLR test. Author

A91-19039#
EFFECT OF THRUST/SPEED DEPENDENCE ON LONG-PERIOD DYNAMICS IN SUPERSONIC FLIGHT
GOTTFRIED SACHS (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1163-1166. refs
Copyright

It is noted that thrust variations with Mach number have virtually no effect on the phugoid in supersonic flight; in particular, it is demonstrated that the positive thrust slope which is often considered strongly phugoid-destabilizing is actually nonexistent. As a corollary, it is shown that autothrottle furnishes no significant means to the improvement of phugoid stability in supersonic flight, in striking distinction to its highly efficient effects in subsonic flight. O.C.

A91-19131#
NUMERICAL CALCULATIONS OF THE BLADE LOADS OF TWO HELICOPTER ROTORS IN MUTUAL INTERFERENCE
THADD C. PATTON (Iowa State University of Science and Technology, Ames) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by NSF. refs
(AIAA PAPER 91-0090) Copyright

The rotor blade loads produced by a hypothetical tandem-rotor helicopter in forward flight are studied using the steady, incompressible, laminar Navier-Stokes' equations in Cartesian coordinates. The rotors are modeled as a distribution of momentum sources whose strengths are calculated from the geometric and aerodynamic characteristics of the rotor blade section. The flow field is solved via an iterative manner using a finite-volume based algorithm. Blade load predictions for a single-rotor helicopter are compared to experimental results. A hypothetical tandem-rotor arrangement is presented to study the effects of the forward rotor's wake onto the aft rotor's blade loads. Author

A91-19172*# Maryland Univ., College Park.
THEORETICAL AND EXPERIMENTAL RESEARCH IN AEROELASTIC STABILITY OF AN ADVANCED BEARINGLESS ROTOR FOR FUTURE HELICOPTERS
JAMES M. WANG (Maryland, University, College Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(Contract NAG2-409; DAAL03-88-C-0002)
(AIAA PAPER 91-0192) Copyright

The aeroelastic stability of a shaft-fixed bearingless rotor is analyzed in wind-tunnel tests for a wide range of operating conditions in order to determine whether such a system could be made aeroelastically stable without incorporating auxiliary dampers. The model rotor and blade properties are determined and used as an input to a bearingless-rotor analysis. Theoretical predictions are compared with experimental results in hover and forward flights. The analysis predicts the lag mode damping satisfactorily for collective pitch between 5 deg and 10 deg; however, the quasi-steady linear aerodynamic modeling overpredicts the damping values for higher collective pitch settings. It is noted that soft blade pitch links improve aeroelastic stability in hover and at low advance ratio. V.T.

A91-19319#
ROTOR DESIGN OPTIMIZATION USING A MULTIDISCIPLINARY APPROACH
F. K. STRAUB, C. B. CALLAHAN, and J. D. CULP (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0477) Copyright

The study addresses the formulation, implementation, and demonstration of a multidisciplinary optimization approach for helicopter-rotor design, utilizing a single comprehensive analysis program capable of performing analyses in all involved disciplines in a consistent and efficient manner. A computer program developed couples a comprehensive helicopter-analysis program with a numerical optimization code to form an optimization tool for the design of rotor blades for improved performance and reduced fuselage vibrations. The resulting code is applied to a helicopter with a modern four-bladed articulated rotor. Results are presented for combined hover/forward flight performance optimization, fuselage vibration reduction, and combined performance/vibration optimization. V.T.

A91-19403#
FLUSH PORT/INERTIALLY BLENDED AIR DATA ESTIMATOR
DEANNA CHISTE KASICH and PETER Y. CHENG (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p.
(AIAA PAPER 91-0670) Copyright

A flush port air data estimation algorithm blends flush port pressure measurements with inertial data to estimate air data parameters. The resulting hybrid estimator provides air data estimates at suitable rates and with suitable fidelity for flight control use even in dynamic maneuvers. To fuse the pressure and inertial data, a non-linear Kalman filter is used. The Kalman filter measurement equations, the process equations, and the statistical matrices of the Kalman filter are discussed. To facilitate running the Kalman filter in real-time, the estimator Kalman gains are precalculated and scheduled instead of propagating matrix equations. The hybrid estimator has been tested using a nose-located, flush port system. Specifically, flight test data, obtained from the High Angle of Attack Research Vehicle Program at the NASA Dryden Flight Research Facility, was used to evaluate the estimator. Preliminary results indicate that the estimates converge. To satisfy low observable air data requirements, work is continuing to expand the estimator for other flush port locations. Author

A91-19409*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
30 X 60 FOOT WIND TUNNEL TEST HIGHLIGHTS FOR AN OVER-THE-TAIL ADVANCED TURBOPROP CONFIGURATION
PAUL L. COE, JR. (NASA, Langley Research Center, Hampton, VA), JOHN N. PERKINS (North Carolina State University, Raleigh), and GRAHAM S. RHODES AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0681) Copyright

This paper presents results from a recent investigation of the static aerodynamic and stability characteristics of a two-surface advanced turboprop aircraft. The conceptual design places Hamilton Standard SR-7 turboprop blades close to the horizontal and vertical tail for potential acoutic shielding. Evaluation of the data shows generally favorable effects of power on aircraft stability and control, and that lateral directional trim can be achieved with one engine inoperative. The tests did show a marked effect of the direction of propeller rotation on thrust minus drag performance. Author

A91-19411#
AN ENHANCED METHOD FOR REDUCING POWER-ON LIFT COEFFICIENT DATA TO POWER-OFF LIFT COEFFICIENT DATA FOR MULTI-ENGINE PROPELLER AIRCRAFT

RONALD N. SEGALL and STEPHANOS GAJDJIS (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by Grumman Corp. refs
(AIAA PAPER 91-0683) Copyright

A methodology correlated with experimental data is developed, in which power-on lift coefficient flight test data is reduced to power-off coefficient data for multiengine propeller driven aircraft. The basic USAF Stability and Control DATCOM is modified for this method; the propeller inflow equations of DeYoung are employed to account for the strong fuselage crossflow effect on the upwash gradient that exists forward of the wing at the propeller disk for an aircraft with wing-mounted propellers in close proximity to the fuselage. The method applied to power-on flight test data for the Grumman E-2C aircraft yielded a power-off lift coefficient that differed from recently published E-2C power-off wind tunnel test data by 0.9-1.7 percent. R.E.P.

A91-19808*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURES TECHNOLOGY DEVELOPMENT FOR HYPERSONIC VEHICLES
CHARLES J. CAMARDA (NASA, Langley Research Center, Hampton, VA) and HAROLD N. MURROW (Lockheed Engineering and Sciences Co., Hampton, VA) ASME, Winter Annual Meeting, Dallas, TX, Nov. 25-30, 1990, Paper. 18 p. refs

This paper summarizes some of the efforts to advance hypersonic structures technology through the National Aero-Space Plane (NASP) Structures Technology Maturation Program. The ranges of expected structural loads and results from analysis and test activities are described. Topics briefly covered include shock impingement effects on aerothermal loads, actively-cooled structures concepts and test results to date for leading edges and panels, design and fabrication of a carbon-carbon control surface, a program for predicting performance of metal matrix composites, an analysis and sizing procedure for thermal structures, and some recently-developed test fixtures for seals, thermal insulation, and actively-cooled panels. Author

N91-13432*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONCEPT DEVELOPMENT OF A MACH 4 HIGH-SPEED CIVIL TRANSPORT
CHRISTOPHER S. DOMACK, SAMUEL M. DOLLYHIGH, FRED L. BEISSNER, JR., KARL A. GEISELHART, MARVIN E. MCGRAW, JR., ELWOOD W. SHIELDS, and EDWARD E. SWANSON (Planning Research Corp., Hampton, VA.) Washington Dec. 1990 30 p
(NASA-TM-4223; L-16603; NAS 1.15:4223) Avail: NTIS HC/MF A03 CSCL 01/3

A study was conducted to configure and analyze a 250 passenger, Mach 4 High Speed Civil Transport with a design range of 6500 n.mi. The design mission assumed an all-supersonic cruise segment and no community noise or sonic boom constraints. The study airplane was developed in order to examine the technology requirements for such a vehicle and to provide an unconstrained baseline from which to assess changes in technology levels, sonic boom limits, or community noise constraints in future studies. The propulsion, structure, and materials technologies utilized in the sizing of the study aircraft were assumed to represent a technology availability date of 2015. The study airplane was a derivative of a previously developed Mach 3 concept and utilized advanced afterburning turbojet engines and passive airframe thermal protection. Details of the configuration development, aerodynamic design, propulsion system, mass properties, and mission performance are presented. The study airplane was estimated to weigh approx. 866,000 lbs. Although an aircraft of this size is a marginally acceptable candidate to fit into the world airport infrastructure, it was concluded that the inclusion of community noise or sonic boom constraints would quickly cause the aircraft to grow beyond acceptable limits using the assumed technology levels. Author

N91-13433*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SEMIEMPIRICAL METHOD FOR OBTAINING FUSELAGE NORMAL AREAS FROM FUSELAGE MACH SLICED AREAS
ROBERT J. MACK and KATHY E. NEEDLEMAN (Lockheed Engineering and Sciences Co., Hampton, VA.) Washington Dec. 1990 15 p
(NASA-TM-4228; L-16614; NAS 1.15:4228) Avail: NTIS HC/MF A03 CSCL 01/3

An aircraft designed to meet low sonic boom or shaped ground overpressure signature requirements has a volume and lift equivalent area distribution which is in close agreement with the equivalent areas of a desired theoretical curve. Final-stage design modifications of the aircraft's geometry to meet this requirement are usually made through adjustments to the fuselage normal cross-section areas that are derived from the corresponding fuselage equivalent areas by iterative methods. The time required to obtain a good agreement between the desired low-boom area distribution and the conceptual aircraft total area distribution can be reduced by using a semi-empirical method which eliminates much of the final trial-and-error iteration previously employed. Fuselages from conceptual aircraft designed to generate low sonic boom ground overpressures at cruise Mach numbers of 2.0 and 3.0 were used as examples to examine the method's capabilities and limitations. Results indicated that the method has merit as a design tool consistent with other linear theory methods. Author

N91-13443*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
THEORETICAL EVALUATION OF ENGINE AUXILIARY INLET DESIGN FOR SUPERSONIC V/STOL AIRCRAFT Final Technical Report
MICHAEL A. BOLES and RICHARD L. HEAVNER Aug. 1988 98 p
(Contract NAG3-608)
(NASA-CR-186610; NAS 1.26:186610) Avail: NTIS HC/MF A05 CSCL 01/3

A higher order panel method is used to evaluate the potential flow of a two dimensional supersonic V/STOL inlet. A non-symmetric analytical inlet model is developed to closely match a wind tunnel model. The analytical inlet is analyzed for flow characteristics around the lower cowl lip and auxiliary inlets. The results are obtained from the output of a computer program that is based on the Hess Panel Method which determines source strengths of panels distributed over a three dimensional body. The analytical model was designed for the implementation of drooped/translated cowl lip and auxiliary inlets as flow improvement concepts. A 40 or 70 degree droop lip can be incorporated on the inlet to determine if these geometry modifications result in flow improvements which may reduce the propensity for flow separation on the interior portion of the lip. Auxiliary inlets are employed to decrease the mass flow over the inlet lip. Thus, the peak flow velocity is reduced at the lip which also lessens the likelihood of flow separation on the interior portion of the lip. A 2, 4, and 6 inch translated lip can be employed to also decrease mass flow over the inlet lower lip in the same manner as the auxiliary inlet. The performance results of the flow improvement concepts show that three possible inlet configurations provide a situation where separation is less likely to occur. A 70 degree droop lip maintains flow conditions such that attached flow over the lower cowl lip may exist for the entire angle of attack range studied. A 0 degree droop and translated lip combination provides similar results for the angle of attack range. The third configuration consists of a 0 degree droop and auxiliary inlet combination. This configuration provides slightly less favorable results than the other two, but still allows for conditions favorable to attached flow within the inlet. Author

N91-13444# Textron Bell Helicopter, Fort Worth, TX.
HELICOPTER STRUCTURAL INTEGRITY PROGRAM (HSIP). VOLUME 1: STRUCTURAL TEST REQUIREMENTS SPECIFICATION Final Report, Nov. 1988 - Dec. 1989
J. MARTIN, J. FILA, and D. REISDORFER Jul. 1990 31 p

(Contract DAAJ02-88-C-0022)
(AD-A226520; BHT-699-099-319-VOL-1; USAAVSCOM-TR-90-D-15A) Avail: NTIS HC/MF A03 CSCL 01/3

This Structural Test Requirements Program is designed to provide the necessary ground test requirements to support the overall HSIP objectives. The Structural Test Requirements portion of the HSIP covers the ground tests which are required during the design development and qualification of rotary-wing/VTOL aircraft. The structural test requirements specification addresses composite and metallic components. Through a comprehensive survey of existing specifications and related documents for structural testing of rotary-wing/VTOL aircraft, key test technology elements such as static, fatigue, durability and damage tolerance were assessed for suitability to future aircraft systems, and evaluated for applicability into the test requirements specification. In cases where no adequate test requirements exist, this program has developed those requirements. A draft test specification was developed and presented to various representatives of the helicopter industry and government agencies at a Government/ Industry Forum. Comments received from the forum participants were evaluated and incorporated, if appropriate, into a final revised specification. GRA

N91-13445*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
F-106B AIRPLANE ACTIVE CONTROL LANDING GEAR DROP TEST PERFORMANCE
WILLIAM E. HOWELL, JOHN R. MCGEHEE, ROBERT H. DAUGHERTY, and WILLIAM A. VOGLER (Lockheed Engineering and Sciences Co., Hampton, VA.) Nov. 1990 12 p
(NASA-TM-102741; NAS 1.15:102741) Avail: NTIS HC/MF A03 CSCL 01/3

Aircraft dynamic loads and vibrations resulting from landing impact and from runway and taxiway unevenness are recognized as significant factors in causing fatigue damage, dynamic stress on the airframe, crew and passenger discomfort, and reduction of the pilot's ability to control the aircraft during ground operations. One potential method for improving operational characteristics of aircraft on the ground is the application of active control technology to the landing gears to reduce ground loads applied to the airframe. An experimental investigation was conducted on series-hydraulic active control nose gear. The experiments involved testing the gear in both passive and active control modes. Results of this investigation show that a series-hydraulic active control gear is feasible and that such a gear is effective in reducing the loads transmitted by the gear to the airframe during ground operations. Author

N91-13446*# Massachusetts Inst. of Tech., Cambridge. Technology Lab. for Advanced Composites.
COMPOSITE FUSELAGE TECHNOLOGY Annual Report, 7 Apr. 1989 - 6 Apr. 1990
MICHAEL J. GRAVES and PAUL A. LAGACE Oct. 1990 25 p
(Contract NAG1-991)
(NASA-CR-187658; NAS 1.26:187658; TELAC-90-19) Avail: NTIS HC/MF A03 CSCL 01/3

The overall objective is to identify and understand, via directed experimentation and analysis, the mechanisms which control the structural behavior of fuselages in their response to damage (resistance, tolerance, and arrest). A further objective is to develop straightforward design methodologies which can be employed by structural designers in preliminary design stages to make intelligent choices concerning the material, layup, and structural configuration so that a more efficient structure with structural integrity can be designed and built. Author

N91-13447*# Douglas Aircraft Co., Inc., Long Beach, CA. Advanced Aircraft Transports High Speed Civil Transport Group.
PROCEDURE FOR GENERATING GLOBAL ATMOSPHERIC ENGINE EMISSIONS DATA FROM FUTURE SUPERSONIC TRANSPORT AIRCRAFT. THE 1990 HIGH SPEED CIVIL TRANSPORT STUDIES
R. A. SOHN and J. W. STROUP Dec. 1990 37 p
(Contract NAS1-18378)
(NASA-CR-181882; NAS 1.26:181882) Avail: NTIS HC/MF A03 CSCL 01/3

The input for global atmospheric chemistry models was generated for baseline High Speed Civil Transport (HSCT) configurations at Mach 1.6, 2.2, and 3.2. The input is supplied in the form of number of molecules of specific exhaust constituents injected into the atmosphere per year by latitude and by altitude (for 2-D codes). Seven exhaust constituents are currently supplied: NO, NO2, CO, CO2, H2O, SO2, and THC (Trace Hydrocarbons). An eighth input is also supplied, NO(x), the sum of NO and NO2. The number of molecules of a given constituent emitted per year is a function of the total fuel burned by a supersonic fleet and the emission index (EI) of the aircraft engine for the constituent in question. The EIs for an engine are supplied directly by the engine manufacturers. The annual fuel burn of a supersonic fleet is calculated from aircraft performance and economic criteria, both of which are strongly dependent on basic design parameters such as speed and range. The altitude and latitude distribution of the emission is determined based on 10 Intern. Air Transport Assoc. (IATA) regions chosen to define the worldwide route structure for future HSCT operations and the mission flight profiles. Author

N91-13448# Aeronautical Research Inst. of Sweden, Stockholm. Dept. of Structures.
DAMAGE TOLERANCE ANALYSIS AND TESTING OF THE FIGHTER AIRCRAFT 37 VIGGEN
BJOERN PALMBERG, MATS OLOF OLSSON, PER OLOF BOMAN, and ANDERS F. BLOM Aug. 1990 13 p Presented at the ICAS 1990, Stockholm, Sweden, 9-14 Sep. 1990
(Contract FMV-82250-89-156-73-001)
(FFA-TN-1990-35; ETN-91-98270) Avail: NTIS HC/MF A03

The Swedish fighter aircraft 37 Viggen was reassessed in terms of damage tolerance evaluation. Four versions of the main wing attachment frame and some components in the fin were subjected to detailed analyses and damage tolerance testing. It was necassary to perform very extensive finite element analyses, in order to get accurate stress distribution in critical sections for subsequent evaluation of three dimensional stress intensity factors. The stress analyses were mainly checked on the basis of traditional static and fatigue testing results available from the design phase of the aircraft. It was concluded that the methodology used is state of the art and that it has been successfully verified. Extension of the original design life may be possible. ESA

N91-13449*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
PERIODIC TRIM SOLUTIONS WITH HP-VERSION FINITE ELEMENTS IN TIME Final Technical Report, 1 Jul. 1989 - 31 Dec. 1990
DAVID A. PETERS and LIN-JUN HOU 20 Dec. 1990 47 p
(Contract NAG1-1027)
(NASA-CR-187705; NAS 1.26:187705) Avail: NTIS HC/MF A01 CSCL 01/3

Finite elements in time as an alternative strategy for rotorcraft trim problems are studied. The research treats linear flap and linearized flap-lag response both for quasi-trim and trim cases. The connection between Fourier series analysis and hp-finite elements for periodic a problem is also examined. It is proved that Fourier series is a special case of space-time finite elements in which one element is used with a strong displacement formulation. Comparisons are made with respect to accuracy among Fourier analysis, displacement methods, and mixed methods over a variety parameters. The hp trade-off is studied for the periodic trim problem to provide an optimum step size and order of polynomial for a given error criteria. It is found that finite elements in time can outperform Fourier analysis for periodic problems, and for some given error criteria. The mixed method provides better results than does the displacement method. Author

N91-13451# Royal Aerospace Establishment, Farnborough (England).
THE UNITED KINGDOM CONTRIBUTION TO THE AGARD FATIGUE-RATED FASTENER SYSTEMS PROGRAM
R. COOK 4 Sep. 1989 74 p
(RAE-TR-89046; RAE-MAT/STR-259; BR114106; ETN-91-98362)
Copyright Avail: NTIS HC/MF A04

The possible values of secondary bending stresses on bolted connections in aircraft wing structures are examined by means of different laboratory test specimens which were designed to determine fatigue performance of some fatigue rated fastener systems. The main objectives are to determine the fatigue life of joints in different materials, to establish the cost of the installed fastener systems, to identify the prime parameters involved in fastener system selection, to generate design data, and to develop a reference data for the comparison of test results produced in different countries using different specimen geometries. It was shown that fastener systems incorporating cold hole expansion or fasteners installed with high interference fits were significantly superior to fasteners installed with a clearance fit in plain holes under the same test conditions. The longest fatigue endurances were observed in joints which contained fastener systems with both cold expansion and a high degree of fastener interference.
ESA

N91-14281# Royal Aeronautical Society, London (England). Aerodynamics Group Committee.
STORE CARRIAGE, INTEGRATION, AND RELEASE
A. B. HAINES *In* AGARD, Missile Aerodynamics 8 p Oct. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The highlights of the conference are summarized and a balanced view of recent developments and prospects for the future in both design and prediction are given. New design concepts (internal carriage, improved launch systems, and active control during launch); mathematical modeling for predictions of store release; development and application of experimental and engineering level prediction methods for installed drag, carriage loads, effects on aircraft stability, and store release trajectories; the RAE Tornado flight research programs to provide data for the evaluation of prediction methods (aircraft flow fields, store carriage loads, and release trajectories); and application of computational fluid dynamics to problems of store carriage and release - design and prediction are discussed.
Author

N91-14323*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD FOR THE DESIGN OF TRANSONIC FLEXIBLE WINGS
LEIGH ANN SMITH and RICHARD L. CAMPBELL Washington Dec. 1990 41 p
(NASA-TP-3045; L-16762; NAS 1.60:3045) Avail: NTIS HC/MF A03 CSCL 01/3

Methodology was developed for designing airfoils and wings at transonic speeds which includes a technique that can account for static aeroelastic deflections. This procedure is capable of designing either supercritical or more conventional airfoil sections. Methods for including viscous effects are also illustrated and are shown to give accurate results. The methodology developed is an interactive system containing three major parts. A design module was developed which modifies airfoil sections to achieve a desired pressure distribution. This design module works in conjunction with an aerodynamic analysis module, which for this study is a small perturbation transonic flow code. Additionally, an aeroelastic module is included which determines the wing deformation due to the calculated aerodynamic loads. Because of the modular nature of the method, it can be easily coupled with any aerodynamic analysis code.
Author

N91-14324# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AIRCRAFT DYNAMIC LOADS DUE TO FLOW SEPARATION
Sep. 1990 274 p In ENGLISH and FRENCH Meeting held in Sorrento, Italy, 1-6 Apr. 1990
(AGARD-CP-483; ISBN-92-835-0582-4; AD-A229616) Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A state-of-the-art review of all types of separated-flow dynamic problems to be encountered in present and future aircraft is provided. In particular, the following topics are presented: evaluation of aerodynamic buffet input characteristics; in-flight and wind tunnel buffeting measurements; and aeroelastic buffeting prediction techniques.

N91-14334# Royal Aerospace Establishment, Bedford (England).
INTERACTION BETWEEN THE CANARD AND WING FLOW ON A MODEL OF A TYPICAL COMBAT AIRCRAFT
D. G. MABEY, B. L. WELSH, and C. R. PYNE *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 19 p Sep. 1990
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The main features of canard/wing interaction were established by a comprehensive test of a half model of a typical combat aircraft in the RAE 13 x 9 ft Low Speed Wind Tunnel. The measurements comprised overall steady forces, buffeting on the wing and the canard, and steady and unsteady pressure distributions on the wing. The results show that the canard effective incidence (determined by the canard setting and the body/wing upwash) controls the canard/wing interaction. With attached flow the canard produces a downwash field which has significant effects when the wing flow is attached. With separated flow on the canard the downwash field is still produced but in addition there is vigorous mixing which inhibits the development of wing flow separations, increasing the overall lift, reducing the wing buffeting and reducing the drag. The process by which this favorable effect is achieved is illustrated by an analysis of the steady and unsteady pressure distributions on the wing at three spanwise sections. These results have important implications with respect to the development and optimization of other canard/wing configurations, particularly at high angles of incidence.
Author

N91-14342# Naval Postgraduate School, Monterey, CA.
DEVELOPMENT OF AN UNMANNED AIR RESEARCH VEHICLE FOR SUPERMANEUVERABILITY STUDIES M.S. Thesis
CHRISTOPHER M. CLEAVER 29 Mar. 1990 53 p
(AD-A227165) Avail: NTIS HC/MF A04 CSCL 01/3

With the advent of all-aspect missiles and highly maneuverable threat aircraft, maintaining air superiority in the future will require innovative solutions to current aerodynamic and propulsive limitations. Unmanned Air Vehicles (UAV's) provide an excellent experimental alternative for supermaneuverability investigations, providing dynamic flight measurements not available in wind tunnels. A 1/8 geometrically scaled F-16A was constructed and test flown in order to provide a proven, highly maneuverable of airspeed, angle of attack, sideslip angle, and control surface deflection. A seven-channel telemetry system was designed to transmit the flight measurement data to a ground station for display and recording. Follow-on research will complete the on-board systems and perform a baseline evaluation for comparison with future flight tests with varied control configurations.
GRA

N91-14343# McDonnell-Douglas Helicopter Co., Mesa, AZ.
ADVANCED TECHNOLOGY LANDING GEAR. VOLUME 1: DESIGN Final Report, Sep. 1985 - Dec. 1989
J. K. SEN Aug. 1990 185 p
(Contract DAAJ02-85-C-0049)
(AD-A227196; MDHC-89-17-VOL-1;
USAAVSCOM-TR-89-D-13A-VOL-1) Avail: NTIS HC/MF A09
CSCL 01/3

The development is described of a retractable, crashworthy, main landing gear system for an LHX-size utility helicopter. The landing gear is of a tricycle configuration and is designed to absorb 60 percent of the energy from a 42 fps level impact condition. The landing gear extends automatically in less than two seconds in an emergency. In the event that the hydraulic and electrical systems fail, the gear is extended with the hydraulic accumulator that primarily supports the helicopter Auxialiary Power Unit. Five sets of landing gears were fabricated in the program. The tests included single gear platform drop tests with level and simulated roll and pitch conditions, and combined pitch (+15 deg) and roll (10 deg) conditions with an iron-bird fixture simulating a helicopter. The tests were conducted for five impact velocities from 10 to 42 fps. The crashworthiness results was very good and demonstrated how analyses can be used to predict the response of landing gears without utilizing expensive tests. The cost of 5000 shipsets over a 13-year production cycle was projected from the cost of fabricated landing gears. GRA

N91-14344# McDonnell-Douglas Helicopter Co., Mesa, AZ.
ADVANCED TECHNOLOGY LANDING GEAR. VOLUME 2: TEST Final Report, Sep. 1985 - Dec. 1989
J. K. SEN Aug. 1990 151 p
(Contract DAAJ02-85-C-0049)
(AD-A227197; MDHC-89-17-VOL-2;
USAAVSCOM-TR-89-D-13B-VOL-2) Avail: NTIS HC/MF A08
CSCL 01/3

The development is described of retractable, crashworthy, main landing gear system for an LHX-size helicopter. The landing gear is of a tricycle configuration and is designed to absorb 60 percent of the energy from a 42 fps level impact condition. The landing gear extends automatically in less than two seconds in an emergency. In the event that the hydraulic and electrical systems fail, the gear is extended with the hydraulic accumulator that primarily supports the helicopter APU. Five sets of landing gears were fabricated in the program. The tests included single gear platform drop tests with level and simulated roll and pitch conditions, and combined pitch (+15 deg) and roll (10 deg) conditions with an iron-bird fixture simulating a helicopter. The tests were conducted for five impact velocities from 10 to 42 fps. The crashworthiness analyses were conducted using program KRASH. The correlation between test and crashworthiness analysis results was very good and demonstrated how analyses can be used to predict the response of landing gears without utilizing expensive tests. The cost of 5000 shipsets over a 13 year production cycle was projected from the cost of the fabricated landing gears. GRA

N91-14345* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WINGTIP VORTEX TURBINE Patent
JAMES C. PATTERSON, JR., inventor (to NASA) 17 Apr. 1990 7 p Filed 28 Oct. 1988 Continuation-in-part of abandoned US-Patent-Appl-SN-004304, filed 5 Jan. 1987 which is a continuation-in-part of abandoned US-Patent-Appl-SN-243685, filed 16 Mar. 1981
(NASA-CASE-LAR-14116-1; US-PATENT-4,917,332;
US-PATENT-APPL-SN-264993; US-PATENT-APPL-SN-004304;
US-PATENT-APPL-SN-243685; US-PATENT-CLASS-244-58;
US-PATENT-CLASS-244-199; US-PATENT-CLASS-290-44;
US-PATENT-CLASS-290-55; INT-PATENT-CLASS-B64D-33/00)
Avail: US Patent and Trademark Office CSCL 01/3

A means for extracting rotational energy from the vortex created at aircraft wing tips which consists of a turbine with blades located in the crossflow of the vortex and attached downstream of the wingtip. The turbine has blades attached to a core. When the aircraft is in motion, rotation of a core transmits energy to a centrally attached shaft. The rotational energy thus generated may be put to use within the airfoil or aircraft fuselage.
Official Gazette of the U.S. Patent and Trademark Office

N91-14346*# Douglas Aircraft Co., Inc., Long Beach, CA.
STRUCTURAL DEVELOPMENT OF LAMINAR FLOW CONTROL AIRCRAFT CHORDWISE WING JOINT DESIGNS Final Report
J. E. FISCHLER, N. M. JERSTAD, F. H. GALLIMORE, JR., and T. J. POLLARD Apr. 1989 195 p
(Contract NAS1-18037)
(NASA-CR-181888; NAS 1.26:181888) Avail: NTIS HC/MF A09
CSCL 01/3

For laminar flow to be achieved, any protuberances on the surface must be small enough to avoid transition to turbulent flow. However, the surface must have joints between the structural components to allow assembly or replacement of damaged parts, although large continuous surfaces can be utilized to minimize the number the number of joints. Aircraft structural joints usually have many countersunk bolts or rivets on the outer surface. To maintain no mismatch on outer surfaces, it is desirable to attach the components from the inner surface. It is also desirable for the panels to be interchangeable, without the need for shims at the joint, to avoid surface discontinuities that could cause turbulence. Fabricating components while pressing their outer surfaces against an accurate mold helps to ensure surface smoothness and continuity at joints. These items were considered in evaluating the advantages and disadvantages of the joint design concepts. After evaluating six design concepts, two of the leading candidates were fabricated and tested using many small test panels. One joint concept was also built and tested using large panels. The small and large test panel deflections for the leading candidate designs at load factors up to +1.5 g's were well within the step and waviness requirements for avoiding transition.The small panels were designed and tested for compression and tension at -65 F, at ambient conditions, and at 160 F. The small panel results for the three-rib and the sliding-joint concepts indicated that they were both acceptable. The three-rib concept, with tapered splice plates, was considered to be the most practical. A modified three-rib joint that combined the best attributes of previous candidates was designed, developed, and tested. This improved joint met all of the structural strength, surface smoothness, and waviness criteria for laminar flow control (LFC). The design eliminated all disadvantages of the initial three-rib concept except for unavoidable eccentricity, which was reduced and reacted satisfactorily by the rib supports. It should also result in a relatively simple low-cost installation, and makes it easy to replace any panels damaged in the field. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A91-17219
ADVANCED HELICOPTER AVIONICS
AVI RAZ (Elbit Computers, Ltd., Haifa, Israel) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 285-287.
Copyright

An account is given of the design features and operational capabilities of an advanced helicopter avionics system which integrates pilot vision, navigation, geographic intelligence, and obstacle data-base components into an affordable package for retrofitting to helicopters ranging from light attack to heavy battlefield cargo types. The design concept for the system was formulated on the basis of Israel Defense Forces helicopter pilot debriefings, which revealed that most helicopter accidents and incidents are due to encounters with known obstables. The mission computer is of parallel-processing type, and both head-up and head-down displays are used, in conjunction wuth night vision goggles. O.C.

A91-17220
MANNED SIMULATION STUDY RESULTS CONCERNING DESIGN PARAMETERS FOR AN EFFECTIVE HELICOPTER OBSTACLE AVOIDANCE SYSTEM (OASYS)
P. H. CERCHIE, B. D. SHIPLEY, R. B. AUST, J. W. WASSON (McDonnell Douglas Helicopter Co., Mesa, AZ), and DONALD REAGO (U.S. Army, Center for Night Vision and Electro-Optics, Fort Belvoir, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 295-303.

The U.S. Army's Center for Night Vision and Electrooptics has prompted an effort to ascertain the field-of-view (FOV), frame-time (FT), and slewing and stabilization requirements for an effective Obstacle Avoidance System ('OASYS'). Four sensor configurations with different values of each of the aforementioned parameters were tested at 200 and 400 m detection ranges. For these test conditions, a 6 x 8-deg FOV and 200-m detection range were unacceptable; a 20 x 30-deg FOV is acceptable in association with adequate stabilization, FT, and detection range; and the 400-m detection range is adequate given suitable FOV, FT, and slewing and stabilization. O.C.

A91-17221
CGAD TACTICAL DATA SYSTEM
DON NELSON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 305-310.

The CGAD Tactical Data System (TDS) design is fundamentally shaped by operator-interface and command-and-control issues associated with complex tactical missions, in which numerous systems are employed in the detection, tracking, and destruction of threats. The environments of these missions vary from 'stand alone', single-vehicle cases to coordinated multiple-vehicle cases. The TDS has been used by the Royal Australian Navy in an antiship surveillance and targetting and ASW mission environment, aboard the S70B-2 helicopter; the TDS has demonstrated a high degree of fault tolerance, a highly structured work-load environment for routine actions' implementation, and a highly flexible interface structure oriented toward flexiblility during mission role and equipment changes. O.C.

A91-17222* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT DATA ACQUISITION METHODOLOGY FOR VALIDATION OF PASSIVE RANGING ALGORITHMS FOR OBSTACLE AVOIDANCE
PHILLIP N. SMITH (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 311-319. refs

An account is given of the methodology used to develop a data base containing low altitude imagery, augmented with the rotorcraft and sensor parameters required for passive-range estimation. The bata base is predicated on flight test data encompassing imagery, rotorcraft and sensor parameters, and ground truth range measurements. Data preparation was conducted by means of a novel technique for obtaining the sensor-calibration parameters. The data-base thus obtained will facilitate further development of computer vision-based obstacle-detection and passive range-estimation algorithms, as well as furnish a benchmark for verification of range estimates against ground-truth estimates. O.C.

A91-17250
OCULOMETER-DEVELOPMENTS FOR DISPLAY CONTROLS
CHRISTOPHER C. SMYTH and MARY E. DOMINESSY (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 663-666.

The measurement of the eye fixation points and dwell times of an individual are of interest to investigators in the field of human factors. Research studies in support of the development of an oculometer for display control in aircraft cockpits are outlined. Results from an experiment involving the performance of an oculometer for data entry on a tactical display are discussed, along with the recent integration of an oculometer with a computer for a stand-alone work station. R.E.P.

A91-17251
NIGHT VISION GOGGLE COMPATIBILITY WITH COLOR DISPLAYS IN ARMY AIRCRAFT - A DISCUSSION OF ISSUES
THOMAS W. DENNISON (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 667, 668.

The Army currently requires that helicopter cockpits comply with MIL-L-85672 for Night Vision Goggle (NVG) compatibility, but this presents problems for Army planners and contractors who want to use color CRTs in avionics systems. MIL-L-85672 is an extremely conservative specification that restricts the use of color (other than Green). This paper presents literature which shows that color displays that do not meet the requirements of MIL-L-85672 can be compatible in practical terms. Rationale is presented to adopt a definition of NVG compatibility that ultimately rests on pilot visual performance through the goggles. If cockpit lighting does not adversely affect vision through the goggles, compatibility is achieved. A strategy is described for developing a measure of NVG compatibility based on pilot visual performance. A side discussion is also presented on a relatively inexpensive way for the Army to achieve NVG compatibility with color displays by increasing the value of the suppression filter on the AN/ANS-6 goggles in the Army inventory. Author

A91-17275
DESIGN CONSIDERATIONS FOR A COUNTERAIR SITUATION AWARENESS DISPLAY FOR ARMY AVIATION
CHRISTOPHER C. SMYTH, FRANK J. MALKIN, and WILLIAM B. DEBELLIS (U.S. Army, Human Engineering Laboratory, Aberdeen Proving Ground, MD) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 921-930. refs

An air combat display concept is proposed for Army aviation helicopter cockpits. The effects of the choice of the display size, the display symbol size, and the area of coverage as a counterair situation awareness display are discussed. The display shows the tracks of aircraft around the host helicopter on a Planar Position Indicator (PPI) graph via the open broadcast radio net of the division-wide air defense radar coverage. It is concluded that with the relatively small display sizes used in helicopters, an accurate determination of the position of enemy threats during air-to-air combat cannot be made by an aviator from the PPI alone. It must be interactive, allowing access to detailed information about a track of interest to be useful. Author

A91-17277* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN IN-FLIGHT INVESTIGATION OF SYMBOLOGY DRIVE LAW IMPROVEMENTS TO AN OPERATIONAL ATTACK HELICOPTER
JEFFERY A. SCHROEDER, WILLIAM S. HINDSON (NASA, Ames Research Center, Moffett Field, CA), and MICHELLE M. ESHOW (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 947-963. refs

A display drive-law design technique developed at Ames

Research Center was applied to the design of the pilot-controlled symbol on a display used in an operational helicopter. A comparison of the newly designed laws and of one documented version of the operational laws was then performed using an in-flight simulation of the helicopter on the NASA/Army CH-47B. Flight-test results indicated that the Ames-developed drive laws were superior to this version of the operational drive laws in terms of task performance and pilot workload. Subsequent postflight-test information suggested that the documentation of the operational drive laws may have been incomplete or in error, even though pilot opinion had corroborated the correctness of the documented operational display in flight. Accordingly, based on additional information, another version of the operational display laws was developed and analyzed, although not flight tested. The revised operational version was compared analytically with the two versions tested in flight. This analysis corroborated that the Ames-developed laws would be superior to this revised version of the operational laws also. A conclusion is that close attention should be paid to the future specification, analysis, and documentation of displayed command-element dynamics, since they have an important effect on task performance and pilot workload. Author

A91-19207*# Massachusetts Inst. of Tech., Cambridge.
ALERT GENERATION AND COCKPIT PRESENTATION FOR AN INTEGRATED MICROBURST ALERTING SYSTEM
CRAIG WANKE and R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by MIT and FAA. refs
(Contract NGL-22-009-640)
(AIAA PAPER 91-0260) Copyright

Alert generation and cockpit presentation issues for low-level wind shear (microburst) alerts are investigated. Alert generation issues center on development of a hazard criterion which allows integration of both ground-based and airborne wind shear detection systems to form an accurate picture of the aviation hazard posed by a particular wind shear situation. A methodology for testing of hazard criteria through flight simulation has been developed, and has been used to examine the effectiveness and feasibility of several possible criteria. Also, an experiment to evaluate candidate graphical cockpit displays for microburst alerts using a piloted simulator has been designed. Author

A91-19335*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FEASIBILITY OF USING A KNOWLEDGE-BASED SYSTEM CONCEPT FOR IN-FLIGHT PRIMARY-FLIGHT-DISPLAY RESEARCH
WENDELL R. RICKS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0503) Copyright

Flight test results have been obtained which demonstrate the feasibility and desirability of using knowledge-based systems architectures for flight test investigations of primary flight display information management-related issues. LISP-based software was used for real-time operation of the primary flight display. The two integrated knowledge-based systems designed to control the primary flight displays were implemented aboard a NASA-Langley B-737. The programmer is noted to be capable of more easily developing initial systems via the present method than with more conventional techniques. O.C.

A91-19404*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE EFFECTS OF PRESSURE SENSOR ACOUSTICS ON AIRDATA DERIVED FROM A HIGH-ANGLE-OF-ATTACK FLUSH AIRDATA SENSING (HI-FADS) SYSTEM
STEPHEN R. WHITMORE and TIMOTHY R. MOES (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 21 p. refs
(AIAA PAPER 91-0671) Copyright

The accuracy of a prototype nonintrusive airdata system derived for high-angle-of-attack measurements was demonstrated for quasi-steady maneuvers as great as 55 degrees during phase one of the F-18 high alpha research vehicle flight test program. This system consists of a matrix of nine pressure ports arranged in annular rings on the aircraft nose, and estimates the complete airdata set utilizing flow modeling and nonlinear regression. Particular attention is paid to the effects of acoustical distortions within the individual pressure sensors of the HI-FADS pressure matrix. A dynamic model to quantify these effects which describes acoustical distortion is developed and solved in closed form for frequency response. R.E.P.

A91-19405*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PRELIMINARY RESULTS FROM AN AIRDATA ENHANCEMENT ALGORITHM WITH APPLICATION TO HIGH-ANGLE-OF-ATTACK FLIGHT
TIMOTHY R. MOES and STEPHEN A. WHITMORE (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 39 p. refs
(AIAA PAPER 91-0672) Copyright

A technique has been developed to improve the fidelity of airdata measurements during dynamic maneuvering. This technique is particularly useful for airdata measured during flight at high angular rates and high angles of attack. To support this research, flight tests using the F-18 high alpha research vehicle were conducted at the NASA Ames Research Center Dryden Flight Research Facility. A Kalman filter was used to combine information from research airdata, linear accelerometers, angular rate gyros, and attitude gyros to determine better estimates of airdata quantities such as angle of attack, angle of sideslip, airspeed, and altitude. This paper briefly develops the state and observation equations used by the Kalman filter and shows how the state and measurement covariance matrices were determined from flight data. Author

A91-19580* John Carroll Univ., Cleveland, OH.
DIGITAL ANGULAR POSITION SENSOR USING WAVELENGTH DIVISION MULTIPLEXING
KLAUS FRITSCH (John Carroll University, Cleveland, OH), GLENN BEHEIM, and JORGE SOTOMAYOR (NASA, Lewis Research Center, Cleveland, OH) IN: Fiber optic and laser sensors VII; Proceedings of the Meeting, Boston, MA, Sept. 5-7, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 453-460. refs
(Contract NAG3-571)
Copyright

Future aircraft will use fly-by-light control systems with fiber-linked optical sensors for such measurands as temperature, pressure, and linear and angular position. A digital optical sensor is described which was developed to transmit the angular position of such slowly rotating parts as a throttle of fuel flow control valve on an aircraft. The sensor employs a reflective code plate with ten channels providing a resolution of 0.35 degrees. Two light-emitting diodes with overlapping spectra are used as light sources. A single microoptic multiplexer-demultiplexer composed of a GRIN rod lens and a miniature grating is used to disperse the spectrum and recombine the spectral components from each channel after reflection by the code plate. The results of preliminary environmental tests of this unit are discussed. The sensor has been operated for brief periods of time between -60 C and +125 without adverse effects. Preliminary vibration tests indicate that the unit will work properly at the maximum vibration levels expected in a jet-engine environment. Author

A91-19626* Litton Guidance and Control Systems, Woodland Hills, CA.
FIBER OPTIC SYSTEMS FOR MOBILE PLATFORMS III; PROCEEDINGS OF THE MEETING, BOSTON, MA, SEPT. 7, 8, 1989
NORRIS E. LEWIS, ED. (Litton Systems, Inc., Poly-Scientific Div., Blacksburg, VA) and EMERY L. MOORE, ED. (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) Meeting sponsored by SPIE, New Mexico State University, JPL, et al.

Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 1173), 1990, 208 p. For individual items see A91-19627 to A91-19634.
(SPIE-1173) Copyright

Various papers on fiber optic systems for mobile platforms are presented. Individual topics addressed include: architecture for fiber optic sensors and actuators in aircraft propulsion systems, fiber optic sensor system readiness for aircraft, microphone headset compatible with power by light, wavelength-division-multiplexed fiber optic sensors for aircraft applications, development of fly-by-light systems, fiber-optic-based inertial measurement unit, fault-tolerant architecture for a fly-by-light flight control computer, optically powered sensors for EMI-immune aviation sensing systems, infrared fiber optic fire sensors for space station applications. Papers on shipboard and automotive applications of fiber optic systems are also included. C.D.

A91-19627* United Technologies Research Center, East Hartford, CT.
ARCHITECTURE FOR FIBER-OPTIC SENSORS AND ACTUATORS IN AIRCRAFT PROPULSION SYSTEMS
W. L. GLOMB, JR. (United Technologies Research Center, East Hartford, CT) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 102-113. Research supported by NASA. refs
Copyright

This paper describes a design for fiber-optic sensing and control in advanced aircraft Electronic Engine Control (EEC). The recommended architecture is an on-engine EEC which contains electro-optic interface circuits for fiber-optic sensors. Size and weight are reduced by multiplexing arrays of functionally similar sensors on a pairs of optical fibers to common electro-optical interfaces. The architecture contains interfaces to seven sensor groups. Nine distinct fiber-optic sensor types were found to provide the sensing functions. Analysis revealed no strong discriminator (except reliability of laser diodes and remote electronics) on which to base a selection of preferred common interface type. A hardware test program is recommended to assess the relative maturity of the technologies and to determine real performance in the engine environment. Author

A91-19628
FIBER OPTIC SENSOR SYSTEM READINESS FOR AIRCRAFT
D. VARSHNEYA (Teledyne Ryan Electronics, San Diego, CA) and W. L. GLOMB, JR. (United Technologies Research Center, East Hartford, CT) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 114-120. refs
Copyright

Advantages of fiber optic technology in an aircraft control system are realized at the system level and not in sensors or components themselves. Improved system reliability and performance, and reduced electro-optic (e-o) interface size, weight and cost may be realized with the use of fiber optic technology. This paper provides a discussion of the Electro-optic Architecture conceptual designs, sensor multiplexing approaches and key design requirements for the control system of the aircraft. In addition, a comparison of Time and Wavelength division multiplexed systems (TDM and WDM) for digital position sensors configured into a network is made to identify which approach meets system design criteria more efficiently. It is concluded that present WDM sensor interrogation time must be drastically reduced to be compatible with the aircraft control system and that both approaches require a highly reliable optical source which provides adequate power and spectral bandwidth. Author

A91-19629
A MICROPHONE HEADSET COMPATIBLE WITH POWER BY LIGHT
A. J. MENDEZ, T.-C. YAO, E. GARMIRE (Southern California, University, Los Angeles, CA), and B. D. SHERMAN (McDonnell Douglas Corp., Long Beach, CA) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 121-127. refs
Copyright

The concept of a microphone headset which operates strictly by power by light (PBL) is addressed. The 'wires' connecting the PBL headset to a station are optical, the signals to and from the headset are optical, and the headset generates its own electrical power by optical to electrical power conversion. The design considerations involved in this bootstrap concept are discussed. C.D.

A91-19631
FIBER OPTIC BASED INERTIAL MEASUREMENT UNIT
A. MATTHEWS (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 147-166.
Copyright

The unique system characteristics of fiber optic gyros are reviewed, and design considerations governing the introduction of fiber optic gyros in mobile platforms are discussed. The characteristics are: flexibility of design, sensitivity, and applicability to fault tolerant designs. The application of fiber optic gyros to two unique mobile platform applications is addressed. C.D.

A91-19632
FAULT TOLERANT ARCHITECTURE FOR A FLY-BY-LIGHT FLIGHT CONTROL COMPUTER
KEVIN THOMPSON, JOHN STIPANOVICH, BRIAN SMITH, and MAHESH REDDY (Boeing Aerospace and Electronics, Seattle, WA) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 167-174.
Copyright

An overview is given of a fault-tolerant in-line monitored optical flight control system now under development. This system uses passive transducers with fiber optic interconnections which promise virtually to eliminate EMI threats to flight control system performance and flight safety and which will provide significant weight savings. Emphasis is given here to the architecture of the optical transducer system required in a fault tolerant flight control system. C.D.

A91-19633
OPTICALLY POWERED SENSORS FOR EMI IMMUNE AVIATION SENSING SYSTEMS
PAUL BJORK, JIM LENZ (Honeywell Systems and Research Center, Minneapolis, MN), BILL EMO, and BOB BIARD (Honeywell, Inc., Micro Switch Div., Freeport, IL) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 175-186.
Copyright

Several different optically powered sensor technologies which have been recently investigated are described. The multiplexing breadboard, proximity switch, throttle lever angle sensor, and pushbutton switch, which have been identified as four important production steps in the development of a family of optically powered sensors for aircraft, are described in terms of configuration, performance, and production status. Related areas in which further research are being conducted are summarized. C.D.

A91-19657
STAGNATION TEMPERATURE PROBES, NUMERICAL PREDICTIONS AND WIND TUNNEL RESULTS
JOSEPH D. BYLES, TIMOTHY W. LAM, and MONTGOMERY R. COATS (Weed Instrument Co., Inc., Aerospace Engineering Div., Round Rock, TX) IN: International Instrumentation Symposium,

35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 103-116. refs
Copyright

The use of advanced computational fluid dynamics is studied with a PC-based viscous-boundary-layer code and traditional wind-tunnel testing in concert, in order to come up with an optimally designed,inertial-separation inlet total-air-temperature probe. In this application the flow is assumed to be two-dimensional, viscous, and compressible, and the flow field is solved utilizing a standard two-dimensional Navier-Stokes solver. An explicit methodology is chosen because it enables easy handling of the multiple zones into which the flow field will be subdivided. Wind-tunnel test results for the lower Mach number incompressible cases are used to infer the sensor's time response, the stagnation recovery factor, and the effects of self-heating and stem conduction. R.E.P.

A91-19709
DIGITAL DATA EXPOSES ENGINE CONDITION
JAMES L. PETTIGREW (Howell Instruments, Inc., Fort Worth, TX) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 799-808. refs
Copyright

Results are presented of a current application of digital data acquisition equipment to the flight test of military helicopters. It is demonstrated that an application of a digital computer to the analysis and the display of data can provide previously unobtainable information on the condition of the turbine engine. The advanced digital data acquisition capabilities of the computer make it possible to monitor continuously the digital values of all parameters and to format the performance data in such a way that the internal condition of the engine could be easily assessed at a glance. Data taken on a good engine, an engine with high exhaust-gas temperature, and an engine with deteriorating compressor are included. I.S.

A91-19710*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
AFTI/F-111 MISSION ADAPTIVE WING FLIGHT TEST INSTRUMENTATION OVERVIEW
KENNETH L. BONNEMA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and WILLIAM A. LOKOS (NASA, Flight Research Center, Edwards, CA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 809-840. refs

The AFTI F-111 Mission Adaptive Wing (MAW) development is described together with the flight test demonstration program. The program developed a smooth variable camber wing and flight control system capable of adjusting the wing's airfoil shape in flight in response to pilot input and flight condition, in order to maximize the aerodynamic efficiency in all areas of flight envelope. This paper examines the instrumentation requirements and the systems implemented and presents the results of flight tests. These results demonstrate the practicality, airworthiness, maintainability, and performance benefits of the smooth variable camber wing system. I.S.

A91-19711
IN-FLIGHT BOUNDARY LAYER PROFILING SYSTEM USING PIEZOELECTRIC SENSOR ARRAYS
G. A. HICKMAN and J. J. GERARDI (Innovative Dynamics, Ithaca, NY) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 841-852. refs
Copyright

A unique passive measurement system for boundary layer transition detection is currently being investigated. The sensor incorporates an arrayed piezoelectric polymer film that converts boundary layer pressure fluctuations into electrical signals. The sensor can be mounted without cutting or drilling the wing surface. Incorporation of a wireless UHF data link will enable simple implementation of a nonintrusive system which can be easily installed on aerodynamic surfaces for in-flight measurements. A data processing and display unit receives and digitally processes the sensor signals and displays the streamwise boundary layer profile in a real-time or averaging mode. Laminar to turbulent transition regions can be discriminated by differences in the pressure levels. Results of preliminary tests to determine the feasibility of this technique to measure boundary layer transition are presented. Author

A91-19807*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WINDSHEAR DETECTION - AIRBORNE SYSTEM PERSPECTIVE
ROLAND L. BOWLES and DAVID A. HINTON (NASA, Langley Research Center, Hampton, VA) Windshear Conference, London, England, Nov. 1, 1990, Paper. 26 p. refs

Functional requirements for airborne windshear detection and warning are discussed based on performance criteria of remote sensor devices such as Doppler radar, Doppler laser radar, and infrared radiometric techniques. These types of sensors are considered able to detect hazardous windshear conditions and provide adequate warning time for the flight crew to escape the encounter. Radar simulation and analysis show that windshear from microbursts can be detected. The Doppler systems can provide line-of-sight information from a region extending 2-4 km in front of the aircraft. The temperature drop associated with the formation of windshear can be measured by an airborne infrared radiometer which compares emission from CO2 in the immediate neighborhood of the aircraft to the emissions from CO2 in the air 4-5 km away. It is suggested that an integration of airborne sensor and ground derived data can support microburst avoidance. B.P.

A91-19810*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED COCKPIT TECHNOLOGY FOR FUTURE CIVIL TRANSPORT AIRCRAFT
JACK J. HATFIELD and RUSSELL V. PARRISH (NASA, Langley Research Center, Hampton, VA) IEEE, The Cockpit of the 21st Century - Will High-Tech Payoff? - Advanced Displays and Controls Topic Annual Symposium, 11th, Dayton, OH, Nov. 28, 1990, Paper. 12 p. refs

A review is presented of advanced cockpit technology for future civil transport aircraft, covering the present state-of-the-art and major technologies, including flat-panel displays, graphics and pictorial displays. Pilot aiding/automation/human-centered design and imaging sensor/flight systems technology (for low-visibility operations) are also presented. NASA Langley Research Center's recent results in pictorial displays and on future developments in large-screen display technologies are discussed. Major characteristics foreseen for the future high-speed civil transport include fault-tolerant digital avionics and controls/displays with extensive human-centered automation, and unusually clean, uncluttered interface with natural crew interaction via touch, voice/tactile means. R.E.P.

N91-13452*# Tennessee Univ. Space Inst., Tullahoma.
A FLIGHT EXPERT SYSTEM FOR ON-BOARD FAULT MONITORING AND DIAGNOSIS Final Report
MOONIS ALI 31 Oct. 1990 52 p
(Contract NAG1-513)
(NASA-CR-187334; NAS 1.26:187334) Avail: NTIS HC/MF A04 CSCL 01/4

An architecture for a flight expert system (FLES) to assist pilots in monitoring, diagnosing, and recovering from inflight faults is described. A prototype was implemented and an attempt was made to automate the knowledge acquisition process by employing a learning by being told methodology. The scope of acquired knowledge ranges from domain knowledge, including the information about objects and their relationships, to the procedural knowledge associated with the functionality of the mechanisms. AKAS (automatic knowledge acquisition system) is the constructed prototype for demonstration proof of concept, in which the expert directly interfaces with the knowledge acquisition system to

ultimately construct the knowledge base for the particular application. The expert talks directly to the system using a natural language restricted only by the extent of the definitions in an analyzer dictionary, i.e., the interface understands a subset of concepts related to a given domain. In this case, the domain is the electrical system of the Boeing 737. Efforts were made to define and employ heuristics as well as algorithmic rules to conceptualize data produced by normal and faulty jet engine behavior examples. These rules were employed in developing the machine learning system (MLS). The input to MLS is examples which contain data of normal and faulty engine behavior and which are obtained from an engine simulation program. MLS first transforms the data into discrete selectors. Partial descriptions formed by those selectors are then generalized or specialized to generate concept descriptions about faults. The concepts are represented in the form of characteristic and discriminant descriptions, which are stored in the knowledge base and are employed to diagnose faults. MLS was successfully tested on jet engine examples. Author

N91-13453*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A PRELIMINARY LOOK AT TECHNIQUES USED TO OBTAIN AIRDATA FROM FLIGHT AT HIGH ANGLES OF ATTACK
TIMOTHY R. MOES and STEPHEN A. WHITMORE Dec. 1990 51 p Presented at the High Angle of Attack Technology Symposium, Hampton, VA, 30 Oct. - 1 Nov. 1990
(NASA-TM-101729; H-1674; NAS 1.15:101729) Avail: NTIS HC/MF A04 CSCL 01/4

Flight research at high angles of attack has posed new problems for airdata measurements. New sensors and techniques for measuring the standard airdata quantities of static pressure, dynamic pressure, angle of attack, and angle of sideslip were subsequently developed. The ongoing airdata research supporting NASA's F-18 high alpha research program is updated. Included are the techniques used and the preliminary results. The F-18 aircraft was flown with three research airdata systems: a standard airdata probe on the right wingtip, a self-aligning airdata probe on the left wingtip, and a flush airdata system on the nose cone. The primary research goal was to obtain steady-state calibrations for each airdata system up to an angle of attack of 50 deg. This goal was accomplished and preliminary accuracies of the three airdata systems were assessed and are presented. An effort to improve the fidelity of the airdata measurements during dynamic maneuvering is also discussed. This involved enhancement of the aerodynamic data with data obtained from linear accelerometers, rate gyros, and attitude gyros. Preliminary results of this technique are presented. Author

N91-14348# Optech, Inc., Downsview (Ontario).
HELICOPTER LIDAR BATHYMETER SYSTEM. CONCEPTUAL DESIGN Final Report
Jun. 1990 213 p
(Contract DACW39-88-D-0039)
(AD-A227057; CERC-90-2) Avail: NTIS HC/MF A10 CSCL 08/3

A technical evaluation is presented of the likely performance of a Helicopter Lidar Bathymeter System (HLBS) that is being developed through an international agreement between the United States and Canada and is implemented through a joint Memorandum of Understanding under the U.S./Canadian Defense Development Sharing Program. Optech, Inc., is developing the HLBS, and the U.S. Army Engineer Waterways Experiment Station is directing the overall development program. The program is in two phases. Phase 1, the developement of a conceptual design, was initiated in March 1988 and completed in March 1989. Phase 2 provides for the detailed design, fabrication, and field testing of an operational prototype system. The conceptual design is presented of the HLBS, which is designed for use from a Bell 212 helicopter at altitudes ranging from 100 to 1,000 m. The system is intended for use in water depths from approx. 1.5 to 35 m. Horizontal control will be provided either by microwave or the NAVSTAR Global Positioning System. GRA

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A91-17109
DETERMINATION OF THE FLOW RATE OF CENTRIFUGAL NOZZLES [OPREDELENIE RASKHODA TSENTROBEZHNYKH FORSUNOK]
I. V. BERSHOVA, E. D. ROMANENKO, V. M. SEMIKIN, and M. V. TKACHENKO Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 40-43. In Russian. refs
Copyright

The distribution of the sprayed fuel over the volume of the combustion chamber of gas-turbine engines can be improved by increasing the number of spray nozzles while simultaneously decreasing their flow rate. Here, some difficulties associated with the design, manufacture, and calibration of low-flow-rate nozzles are briefly examined. The general design and operation of a newly developed photoelectic instrument for determining the flow rate of fuel nozzles are described, and the flow rate characteristics of centrifugal nozzles are presented. V.L.

A91-17213
ADVANCED METHODS OF HELICOPTER PROPULSION SYSTEM INTEGRATION/AIR MANAGEMENT SYSTEM DESIGN
KEITH E. BOYD and EDWARD MURGIA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 213-226.
Copyright

Advanced methods for accurately calculating the performance of helicopter propulsion/air management systems have been developed. These methods permit the rapid investigation of a large matrix of separate, related ways of meeting total airflow and power management requirements of modern helicopters. Performance comparison maps are generated in very short times that make valid comparisons of the several systems parameters permitting extensive optimization of proposed systems to meet performance, weight and reliability goals. Included in these systems requirements are engine bay cooling, engine and transmission oil cooling, air intake and particle separator definition, environmental control system definition and exhaust plume/hot metal IR signature suppression. Author

A91-17647#
CAN YOUR TURBINE SURVIVE A HALF CENTURY
GEORGE J. POND (Textron Lycoming, Stratford, CT) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 4 p.

Turbine engines do not typically suffer the same problems as helicopter airframes after extended time in service, i.e., cumulative effects of exposure to environmental elements. Periodic overhauls or major inspections generally precipitate repair or replacement of virtually all significant hardware long before the aging process becomes significant. The more common problem facing turbine engine manufacturers is the aging of the technology within their products. This paper will deal with some of the approaches taken by a turbine engine manufacturer in supporting an aging fleet. It will also address the issue of implementation of later technology into earlier model engines. Author

A91-17985
NUMERICAL ANALYSIS OF FORCED VIBRATIONS OF A CRANKSHAFT-AIRSCREW SYSTEM
Z. DZYGADLO and W. SOBIERAJ (Wojskowa Akademia Techniczna, Warsaw, Poland) Journal of Technical Physics (ISSN 0324-8313), vol. 30, no. 2, 1989, p. 243-256. refs
Copyright

The discrete structure of a crankshaft-airscrew dynamic model, composed of finite deformable beam and shaft elements as well as rigid elements is considered. It is assumed that the engine crankshaft is supported on elastic-damping supports. The presence of a planetary reduction gear is taken into account by introducing two rigid single-node elements or a two-node element into the discrete scheme. The matrix of inertia of the reduction gear is determined, followed by the matrices of rigidity, damping, and inertia of a crankshaft-airscrew system. A solution of the problem of steady forced vibrations of a crankshaft-airscrew system due to the action of external harmonic loads is obtained, and a numerical analysis is applied in order to determine the displacements of a crankshaft-airscrew system. The resonance characteristics of the crankshafts of two types of seven-cylinder radial engines are derived. V.T.

A91-18080
AUTOMATIC CONTROL AND DIAGNOSTICS OF FLIGHT VEHICLE POWERPLANT CONTROL SYSTEMS [AVTOMATICHESKII KONTROL' I DIAGNOSTIKA SISTEM UPRAVLENIIA SILOVYMI USTANOVKAMI LETATEL'NYKH APPARATOV]
VLADIMIR I. VASIL'EV, IURII M. GUSEV, ANATOLII I. IVANOV, V. A. SEMERAN, and S. A. SIROTIN Moscow, Izdatel'stvo Mashinostroenie, 1989, 240 p. In Russian. refs
Copyright

The principles and methods of the design of automatic control systems for the powerplants of flight vehicles are examined. A general statement of the statistical classification control problem is presented, and an approach to system control and diagnostics is proposed which is based on the identification of the dynamic parameters of the system. Some aspects of the control and diagnostics of analog and digital electronic control systems are discussed, as are ways of increasing the reliability of these systems. V.L.

A91-18085
STANDARDIZATION OF AVIATION ENGINES: A TECHNICAL AND ECONOMIC JUSTIFICATION [UNIFIKATSIIA AVIADVIGATELEI: TEKHNIKO-EKONOMICHESKOE OBOSNOVANIE]
PETR A. NECHAEV and ALEKSANDR V. PRIGOZHIN Moscow, Izdatel'stvo Transport, 1990, 168 p. In Russian. refs
Copyright

Strategies for the development of a parametric series of original and standardized aviation engines for a fleet of aircraft are examined from the standpoint of their technical feasibility and cost effectiveness. A method is presented for determining the cost effectiveness limits of powerplant subsystem standardization. Mathematical models are proposed for calculating the operation and capital costs and the expected advantages and disadvantages of standardization in relation to the technical, economic, and organization factors over the different stages of the life cycle. V.L.

A91-18250
VECTOR PUSHES AHEAD WITH TPF351
JOHN BAILEY Flight International (ISSN 0015-3710), vol. 138, Nov. 28-Dec. 4, 1990, p. 30-34.
Copyright

Garrett's new TPF351-20 pusher turboprop, which powers the Embraer/FAMA CBA 123 Vector commuter aircraft, draws on the established technology of the long-running TPE331 (T76 military) series. This 2000 shp engine comprises a two-stage centrifugal compressor, stacked-ring combustor and three-stage axial high-pressure turbine. The design is modular, permitting easy disassembly for on-the-wing maintenance, and features a digital integrated engine computer. For easy maintainability the engine breaks down into six modules that can be installed or removed while the engine is mounted on the aircraft, without any balancing involved. A full-authority digital engine control provides automatic start, automatic torque and temperature limiting, trend monitoring and fault detection. R.E.P.

A91-18902*# Missouri Univ., Rolla.
ANALYTICAL STUDY OF WIND-TUNNEL ACOUSTIC TESTING OF PROPELLERS
WALTER EVERSMAN (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 27, Oct. 1990, p. 851-858. Research supported by NASA. Previously cited in issue 13, p. 2050, Accession no. A89-33737. refs
Copyright

A91-19128#
AEROACOUSTIC INVESTIGATION OF SHROUDED COUNTER-ROTATING PROPELLERS
REBECCA L. SQUIRES and WILLIAM E. MILHOLEN, II AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p.
(AIAA PAPER 91-0087) Copyright

Anechoic-chamber tests have been conducted to ascertain the aeroacoustic characteristics of a counterrotating propeller (CRP) model. The data obtained indicate that overall CRP noise levels increase with the addition of a shroud and further increase with greater shroud length. The method of shroud installation and its associated wakes create both noise and propeller performance alterations. In all cases, the forward and rear rotor sound pressure levels underwent alteration, exhibiting increased upstream and downstream directivity. The interaction tone sound pressure level appears to be independent of forward and rear rotor variations. O.C.

A91-19290#
AN EFFICIENT TWO-DIMENSIONAL ENGINEERING DESIGN CODE FOR SCRAMJET COMBUSTOR, NOZZLE, AND PLUME ANALYSIS
HOUSHANG B. EBRAHIMI (Rockwell International Corp., Downey, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0416) Copyright

The development of a computer program to analyze the turbulent reacting flow field in a two-dimensional supersonic combustor, nozzle, and external flow configuration is described. This program can be used to solve the parabolized Navier-Stokes and species equations in fully vectorized form. The present code was also applied to flow fields in which fuel was injected transversely into a supersonic airstream. K.K.

A91-19317#
TWO-DIMENSIONAL THRUST VECTORING NOZZLE OPTIMIZATION TECHNIQUES
E. G. KING, JR., L. M. FREEMAN, K. W. WHITAKER (Alabama, University, Tuscaloosa), and C. L. KARR (U.S. Bureau of Mines, Tuscaloosa Research Center, AL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0473) Copyright

The elimination of heavy thrust vectoring devices in favor of using a movable nozzle contour that will turn the flow by the utilization of shock and expansion waves is investigated. For this study, a genetic algorithm (GA) is utilized to define the optimum nozzle contour that achieves the greatest exhaust flow vectoring angles. This is accomplished by permitting the GA to manipulate the location of a set of discretized points that represent the nozzle contour. Thus, with the appropriate objective function, the GA can evaluate the different contours it generates to arrive at one which creates the best flow turning angle. R.E.P.

A91-19366#
THE EFFECTS OF NOZZLE GEOMETRY UPON SONIC FUEL INJECTION AS STUDIED BY OH-FLOW-TAGGING VELOCIMETRY
T. H. CHEN, L. P. GOSS, D. D. TRUMP, B. SARKA (Systems Research Laboratories, Inc., Dayton, OH), and A. S. NEJAD (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs

(Contract F33615-88-C-2832)
(AIAA PAPER 91-0575)

This paper describes the application of a novel flow-tagging-velocimetry technique to the study of the effects of nozzle geometry upon sonic fuel injection. The flow-tagging technique consists of the photofragmentation of water vapor by ultraviolet radiation to form OH radicals. The radicals serve to tag the flow and are monitored after a known time delay by laser-induced fluorescence to determine their displacement. Velocity profiles of several small sonic jets (operated near Mach 2) taken with the OH-Flow-Tagging technique indicate that the initial shear-layer thickness (about 0.5 mm) is approximately the same as the wall thickness of the nozzle tube. A comparison of flat-tipped and inner-tapered nozzles indicates that the former develops a thicker shear layer and promotes better mixing between the fuel jet and the surrounding air. Author

A91-19368#
LASER-INITIATED CONICAL DETONATION WAVE FOR SUPERSONIC COMBUSTION
G. CARRIER, F. FENDELL, D. MCGREGOR, S. COOK, and M. VAZIRANI (TRW Space and Technology Group, Redondo Beach, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract F49620-87-C-0081)
(AIAA PAPER 91-0578) Copyright

The feasibility of the operation of an air-breathing supersonic combustor based on a stabilized, conically configured oblique-detonation wave generated by the interaction of a train of spherical-detonation waves has been theoretically investigated. The detonation waves are directly initiated by a very rapidly pulsed laser whose beam is tightly focused on a fixed site in a steady, uniform supersonic stream of combustible gas. Downstream of the detonation, the expanding supersonic isentropic inviscid flow is self-similar. The combustor is idealized as a circular cross-section pipe lying upwind of the axial position at which the conical detonation wave interacts with the wall; downwind, the reacted gas flow is no longer self-similar, thereby prompting the present search for a practically scaled axisymmetric nozzle configuration. O.C.

A91-19391#
GAS TURBINE COMBUSTOR PERFORMANCE EVALUATION
N. K. RIZK and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0640) Copyright

In the effort to enhance the performance of a production gas turbine combustor, a three-dimensional analytical model was utilized to evaluate the characteristics of the flow field within the liner. the combustor went through a number of hardware modifications including the addition of dome swirlers, changing primary holes configuration, and altering the dome cooling schedule. The analysis indicated that the inclusion of dome swirler in the combustor design had enhanced evaporation and mixing in the primary zone that resulted in significant reduction in exhaust smoke levels. The modifications made to alleviate potential carboning problems on the liner walls have caused favorable changes in the fuel distribution, as predicted by the three-dimensional model and confirmed experimentally. The predictions of an empirical/analytical calculation approach have demonstrated the capability of the approach to accurately simulate the impact of systematic modifications to the details of the combustor on its performance. Regions of potential emissions formation and performance deficiency are more readily defined using the three-dimensional analysis. Author

A91-19448*# Toledo Univ., OH.
CASCADE FLUTTER ANALYSIS WITH TRANSIENT RESPONSE AERODYNAMICS
MILIND A. BAKHLE, APARAJIT J. MAHAJAN, THEO G. KEITH, JR. (Toledo, University, OH), and GEORGE L. STEFKO (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(Contract NSG-3139)
(AIAA PAPER 91-0747) Copyright

Two methods for calculating linear frequency domain aerodynamic coefficients from a time-marching Full-Potential cascade solver are developed and verified. In the first method, the Influence Coefficient method, solutions to elemental problems are superposed to obtain the solutions for a cascade in which all blades are vibrating with a constant interblade phase angle. The elemental problem consists of a single blade in the cascade oscillating while the other blades remain stationary. In the second method, the Pulse Response method, the response to the transient motion of a blade is used to calculate influence coefficients. This is done by calculating the Fourier transforms of the blade motion and the response. Both methods are validated by comparison with the Harmonic Oscillation method and give accurate results. The aerodynamic coefficients obtained from these methods are used for frequency domain flutter calculations involving a typical section blade structural model. An eigenvalue problem is solved for each interblade phase angle mode and the eigenvalues are used to determine aeroelastic stability. Flutter calculations are performed for two examples over a range of subsonic Mach numbers using both flat plates and actual airfoils. Author

A91-20015
INFLUENCE OF FLOW MIXING ON THE PERFORMANCE OF A TURBOFAN ENGINE OF HIGH BY-PASS RATIO
S. LOESCH Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, Oct. 1990, p. 333-341. refs
Copyright

Thermodynamic procedures in a mixed flow engine are analyzed using a model of the mixer geometry and the mixing thermodynamics. Thrust and 'sfc' variation are compared in a projected mixed flow engine and a hypothetical separated flow engine with the same cycle conditions. The mixed flow concept is found to offer a small gain in engine economy for long-range aircraft due to small consumption gains and noise reduction. C.D.

A91-20387#
ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF BIRD IMPACT ON BLADES
DEPING GAO (Nanjing Aeronautical Institute, People's Republic of China) and QINGHONG LI (China Eastern Airlines, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Oct. 1990, p. 335-338. In Chinese, with abstract in English. refs

The high-speed dynamics of bird impact on blades has been studied analytically and experimentally. A program system for the nonlinear transient response analysis has been developed and the loading characteristics of the bird impact are outlined. Based on the sensibility analysis of structural response to loading, a simple effective loading model of the bird impact is presented. A computer program of model analysis for the bird impact on blades is developed. The calculational results show that the bird impact on the blade at the velocity about 200 m/s can be characterized as compressible fluid. Normal impact experiments with artificial birds have been completed, and the course of the bird impact was recorded by the high-speed photography. It is proved that the bird colliding against the blade behaves like compressible fluid. Author

A91-20388#
EFFECT OF INLET DISTORTION ON BLADE VIBRATION AND INLET DISTORTION TOLERANCE
QUN CHEN, SHAOHUI DU, and WENLAN LI (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Oct. 1990, p. 339-342. In Chinese, with abstract in English.

This paper examines the acceptability of inlet distortion with respect to the blade strength, and considers the influence of some inlet distortion patterns on the compressor blades vibration. The

exciting forces of the circumferential distortion on the compressor blades and the blade responses to these forces are analyzed. The blade vibratory stresses caused by the distortion are calculated. The stress variation at different distortion levels is also investigated, and so the inlet distortion tolerance limit determined by the blade strength is discussed. Author

A91-20393#
NATURAL VIBRATION ANALYSIS OF TURBOMACHINERY DISK WITH SMALL MISTUNED BLADES
HAO WANG and WENLIANG WANG (Fudan University, Shanghai, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Oct. 1990, p. 357-360. In Chinese, with abstract in English. refs

A numerical approach is developed for natural vibration analysis of turbomachinery disk with small mistuned blades by using modal synthesis technique. Due to lack of rotational periodicity, the group theory method for the tuned bladed-disk assemblies is not applicable to the mistuned ones. According to the matrix perturbation theory, the modes used for synthesis in this paper are taken from a tuned bladed-disk corresponding to the small mistuned one. This new technique keeps the advantages of the group theory method and makes the final eigenvalue problem of small size. A computer program has been written to analyze the natural vibration characteristics of turbomachinery disk with small mistuned blades. The computational results prove that the method is very efficient. Author

N91-13456*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL AND STRUCTURAL ASSESSMENTS OF A CERAMIC WAFER SEAL IN HYPERSONIC ENGINES
MIKE T. TONG (Sverdrup Technology, Inc., Brook Park, OH.) and BRUCE M. STEINETZ 1991 11 p Proposed for presentation at the 27th Joint Propulsion Conference, Sacramento, CA, 24-27 Jun. 1991; cosponsored by AIAA, ASME, SAE, and ASEE
(NASA-TM-103651; E-5840; NAS 1.15:103651) Avail: NTIS HC/MF A03 CSCL 21/5

The thermal and structural performances of a ceramic wafer seal in a simulated hypersonic engine environment are numerically assessed. The effects of aerodynamic heating, surface contact conductance between the seal and its adjacent surfaces, flow of purge coolant gases, and leakage of hot engine flow path gases on the seal temperature were investigated from the engine inlet back to the entrance region of the combustion chamber. Finite element structural analyses, coupled with Weibull failure analyses, were performed to determine the structural reliability of the wafer seal. Author

N91-13457*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN AD100 IMPLEMENTATION OF A REAL-TIME STOVL AIRCRAFT PROPULSION SYSTEM
PETER J. OUZTS and COLIN K. DRUMMOND 1990 20 p Presented at the 4th Annual Conference of the Applied Dynamics International Users' Society of the Central/Northeastern Regions, Warren, MI, 1-2 Oct. 1990
(NASA-TM-103683; E-5901; NAS 1.15:103683) Avail: NTIS HC/MF A03 CSCL 21/5

A real-time dynamic model of the propulsion system for a Short Take-Off and Vertical Landing (STOVL) aircraft was developed for the AD100 simulation environment. The dynamic model was adapted from a FORTRAN based simulation using the dynamic programming capabilities of the AD100 ADSIM simulation language. The dynamic model includes an aerothermal representation of a turbofan jet engine, actuator and sensor models, and a multivariable control system. The AD100 model was tested for agreement with the FORTRAN model and real-time execution performance. The propulsion system model was also linked to an airframe dynamic model to provide an overall STOVL aircraft simulation for the purposes of integrated flight and propulsion control studies. An evaluation of the AD100 system for use as an aircraft simulation environment is included. Author

N91-13458*# Cornell Univ., Ithaca, NY.
THEORY OF FINITE DISTURBANCES IN A CENTRIFUGAL COMPRESSION SYSTEM WITH A VANELESS RADIAL DIFFUSER Final Report
F. K. MOORE Dec. 1990 68 p
(Contract NAG3-349)
(NASA-CR-187049; NAS 1.26:187049) Avail: NTIS HC/MF A04 CSCL 21/5

A previous small perturbation analysis of circumferential waves in circumferential compression systems, assuming inviscid flow, is shown to be consistent with observations that narrow diffusers are more stable than wide ones, when boundary layer displacement effect is included. The Moore-Greitzer analysis for finite strength transients containing both surge and rotating stall in axial machines is adapted for a centrifugal compression system. Under certain assumptions, and except for a new second order swirl, the diffuser velocity field, including resonant singularities, can be carried over from the previous inviscid linear analysis. Nonlinear transient equations are derived and applied in a simple example to show that throttling through a resonant value of flow coefficient must occur in a sudden surge-like drop, accompanied by a transient rotating wave. This inner solution is superseded by an outer surge response on a longer time scale. Surge may occur purely as result of circumferential wave resonance. Numerical results are shown for various parametric choices relating to throttle schedule and the characteristic slope. A number of circumferential modes considered simultaneously is briefly discussed. Author

N91-14349*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMBUSTOR TECHNOLOGY FOR FUTURE AIRCRAFT
ROBERT R. TACINA 1990 17 p Presented at the 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990; cosponsored by AIAA, SAE, ASME, and ASEE Previously announced in IAA as A90-47219
(NASA-TM-103268; E-5707; NAS 1.15:103268; AIAA-90-2400) Avail: NTIS HC/MF A03 CSCL 21/5

The continuing improvement of aircraft gas turbine engine operating efficiencies involves increases in overall engine pressure ratio increases that will result in combustor inlet pressure and temperature increases, greater combustion temperature rises, and higher combustor exit temperatures. These conditions entail the development of fuel injectors generating uniform circumferential and radial temperature patterns, as well as combustor liner configurations and materials capable of withstanding increased thermal radiation even as the amount of cooling air is reduced. Low NO(x)-emitting combustor concepts are required which will employ staged combustion. The development status of component technologies answering these requirements are presently evaluated. Author

N91-14350# Purdue Univ., West Lafayette, IN. Thermal Sciences and Propulsion Center.
RESEARCH AS PART OF THE AIR FORCE RESEARCH IN AERO-PROPULSION TECHNOLOGY (AFRAPT) PROGRAM Annual Summary Report, 15 Aug. 1988 - 14 Oct. 1990
SANFORD FLEETER 1 Aug. 1990 5 p
(Contract AF-AFOSR-0261-88; AF PROJ. 2308)
(AD-A226893; AFOSR-90-0961TR) Avail: NTIS HC/MF A01 CSCL 21/5

Nine graduate students participated in the AFRAPT Program during this time period. Two students have completed their M.S.M.E. programs and are currently employed at one of the AFRAPT participating companies. Four students have nearly completed their thesis research, with one student having withdrawn. The other two continuing and new students have initiated their thesis research and are making good progress. GRA

N91-14351# Detroit Diesel Allison, Indianapolis, IN.
FATIGUE AND FRACTURE OF TITANIUM ALUMINIDES, VOLUME 2 Final Report, 1 Jul. 1985 - 31 Jul. 1989
M. L. GAMBONE Feb. 1990 235 p
(Contract F33615-85-C-5111; AF PROJ. 2420)

(AD-A227353; ALLISON-EDR-14249-VOL-2; WRDC-TR-89-4145-VOL-2) Avail: NTIS HC/MF A11 CSCL 11/6

Titanium aluminide composites hold great promise for application in the later stages of advanced compressor systems. This conclusion is based on the assumption that Ti3Al composites can achieve the fatigue strength levels projected from data for the SiC/Ti 6Al-4V composite system yet remain stable to 650 C or higher temperatures. In the limited results to date, Ti3Al composite specimens have exhibited a minimum of fiber/matrix interaction, good strength stiffness, and significantly better fatigue strength than monolithic Ti3Al. The good fatigue and high stiffness are essential for application to the high temperature compressor spacers in the minimum-weight rotor configuration being developed. The key material design parameters for titanium aluminides and titanium aluminide composites must be identified and understood. These parameters include the fatigue and fracture behavior (crack initiation and propagation as a function of temperature, frequency, size, and stress ratio), the near threshold stress intensity crack growth rates, and the thermomechanical fatigue behavior. GRA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A91-17114
TRACKING OF AIRCRAFT FLIGHT CHARACTERISTICS BY THE METHOD OF PERIODIC MOTION PREDICTION [OTSLEZHIVANIE LETNYKH KHARAKTERISTIK SAMOLETA METODOM PERIODICHESKOGO PROGNOZIROVANIIA DVIZHENIIA]
L. P. FEDOROV and R. V. KOZIN Samoletostroenie - Tekhnika Vozdushnogo Flota (ISSN 0581-4634), no. 56, 1989, p. 59-64. In Russian. refs
Copyright

An approach to aircraft tracking is proposed whereby the control functions are selected by the method of periodic prediction. The tracking of the specified take-off and landing characteristics of an aircraft with allowance for motion relative to the center of mass is examined as an example. Control is determined in a class of specified functions, such as piecewise constant or piecewise linear continuous functions. The approach proposed here can be used for automatic aircraft control during the flight. V.L.

A91-17202
AN EVALUATION OF ACTIVE CONTROL OF STRUCTURAL RESPONSE AS A MEANS OF REDUCING HELICOPTER VIBRATION
ALAN E. STAPLE (Westland Helicopters, Ltd., Yeovil, England) (European Rotorcraft Forum, 15th, Amsterdam, Netherlands, Sept. 12-15, 1989) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 3-17. Research supported by the Ministry of Defence and Royal Aerospace Establishment.
Copyright

An account is given of the design, implementation, and testing of the Active Control of Structural Response (ACSR) technique for helicopter structural vibration reduction. ACSR uses high-frequency force actuators located within the vibrating structure; the responses generated by these secondary actuator forces are superposed on the baseline response generated by the primary vibratory forcing source, namely the main rotor, thereby minimizing structural response. Attention is given to the implementation of an ACSR system on the Westland 30 helicopter, as well as the results of both ground vibration tests and flight trials. O.C.

A91-17203
TEST AND EVALUATION OF FUSELAGE VIBRATION UTILIZING ACTIVE CONTROL OF STRUCTURAL RESPONSE (ACSR) OPTIMIZED TO ADS-27
WILLIAM A. WELSH, PAUL C. VON HARDENBERG, PAUL W. VON HARDENBERG (Sikorsky Aircraft, Stratford, CT), and ALAN E. STAPLE (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 21-37. refs
Copyright

A shake test was conducted to evaluate an Active Control of Structural Response (ACSR) system on a modified S-76B aircraft. Results confirm that the ACSR system is able to simultaneously control vibration of multiple airframe response frequencies, including 1P, to levels below ADS-27 specifications while suppressing engine vibration to levels lower than required. ACSR is characterized by high speed reaction times to transient conditions, low power consumption and a minimal weight penalty. The ACSR system consists of airframe mounted accelerometers, a digital control computer, and a set of actuators mounted across the airframe/main transmission interface. The computer implements an adaptive control algorithm which identifies the airframe response/actuator force transfer matrix and applies conventional control techniques to generate actuator gains to cancel airframe vibration levels. Author

A91-17206
ON CHAOS METHODS APPLIED TO HIGHER HARMONIC CONTROL
MARTI M. SARIGUL-KLIJN, RAMESH KOLAR, E. ROBERTS WOOD (U.S. Naval Postgraduate School, Monterey, CA), and FRIEDRICH K. STRAUB (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 79-98. Research supported by the U.S. Navy and McDonnell Douglas Helicopter Co. refs
Copyright

The geometric and topological methods of chaos theory are presently applied to flight test data from an OH-6A test aircraft's Higher Harmonic Control (HHC) system, whose role is the active suppression of helicopter vibrations. For a given helicopter, the presence of chaos imposes a limit on possible HHC vibration reduction. The present method exploits the relationship between the Poincare section and Van der Pol plane chaos methods and the vibration amplitude and phase. This allows the rapid determination of optimum phase for an HHC controller and defines minimum HHC controller requirements for any helicopter on the basis of a few minutes' worth of flight test data. O.C.

A91-17230* California Univ., Los Angeles.
NONLINEAR COUPLED ROTOR-FUSELAGE HELICOPTER VIBRATION STUDIES WITH HIGHER HARMONIC CONTROL
P. P. FRIEDMANN, C. VENKATESAN (California, University, Los Angeles), and I. PAPAVASSILIOU IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 429-445. refs
(Contract NAG2-477; DAAL03-86-G-0109)
Copyright

This paper addresses the problem of vibration prediction and vibration reduction in helicopters by means of active control methodologies. The nonlinear equations of a coupled rotor/flexible-fuselage system have been derived using computer algebra, thus relegating this tedious task to the computer. In the solution procedure the trim state and vibratory response of the helicopter are obtained in a single pass by using a harmonic balance technique and simultaneously satisfying the trim and the vibratory response of the helicopter in all the rotor and fuselage degrees of freedom. Using this solution procedure, the influence of the fuselage flexibility on the vibratory response is studied. In addition, it is shown that the conventional single frequency HHC is capable of reducing either the hub loads or only the fuselage vibrations

but not both simultaneously. A new scheme called MHHC, having multiple higher harmonic pitch inputs, was used to accomplish this task of simultaneously reducing both the vibratory hub loads and fuselage vibratory response. In addition, the uniqueness of this MHHC scheme is explained in detail. Author

A91-17278
AN EVALUATION OF THE PROPOSED SPECIFICATION FOR HANDLING QUALITIES OF MILITARY ROTORCRAFT, MIL-H-8501B, UTILIZING PREDICTED AND ACTUAL SH-60B HANDLING QUALITIES
A. N. CAPPETTA and J. B. JOHNS (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 965-978. refs
Copyright

As part of the effort to mature the proposed specification for handling qualities of military rotorcraft, MIL-H-8501B, an evaluation of this specification was performed utilizing predicted and actual SH-60B handling qualities. SH-60B dynamic characteristics used for comparison with MIL-H-8501B dynamic requirements were obtained from a validated SH-60B nonlinear math model. Both frequency and time responses were generated as required for comparison with relevant sections of the proposed specification. This comparison revealed lessons learned with regard to the application of small, moderate, and large amplitude criteria. Actual SH-60B handling qualities data were obtained from flight tests conducted by the Naval Air Test Center. Pilot opinion data from these tests were then correlated with the predicted handling qualities obtained through comparison of the SH-60B dynamics and MIL-H-8501B requirements. Through this correlation hover and low-speed pitch and yaw, and forward flight roll criteria were evaluated. This evaluation revealed support for a majority of MIL-H-8501B criteria. Author

A91-17279
INITIAL FLIGHT TEST ASSESSMENT OF V-22 FLYING QUALITIES
C. DABUNDO (Boeing Helicopters, Ridley Park, PA) and D. KIMBALL (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 979-994. refs
Copyright

First flight of the V-22 tiltrotor was accomplished on March 19, 1989. Initial flight testing of the V-22 has involved three aircraft whose primary tasks are envelope expansion, flying qualities evaluation, and flight controls and avionics development. This paper addresses the flying qualities evaluation of the V-22 on the Primary Flight Control System, that is, with a minimum of stability-and-control augmentation. Author

A91-17280* Maryland Univ., College Park.
FORMULATION AND VALIDATION OF HIGH-ORDER LINEARIZED MODELS OF HELICOPTER FLIGHT MECHANICS
FREDERICK D. KIM, ROBERTO CELI (Maryland, University, College Park), and MARK B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 995-1002. refs
(Contract NCA2-310)
Copyright

A high-order linearized model of helicopter flight dynamics is extracted from a nonlinear time domain simulation. The model has 29 states that describe the fuselage rigid body degrees of freedom, the flap and lag dynamics in a nonrotating coordinate system, the inflow dynamics, the delayed entry of the horizontal tail into the main rotor wake, and, approximately, the blade torsion dynamics. The nonlinear simulation is obtained by extensively modifying the GENHEL computer program. The results indicate that the agreement between the linearized and the nonlinear model is good for small perturbations, and deteriorates for large amplitude maneuvers. Author

A91-17281
A THEORY FOR THE ANALYSIS OF ROTORCRAFT OPERATING IN ATMOSPHERIC TURBULENCE
MARK F. COSTELLO (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1003-1015. refs
Copyright

A new model describing atmospheric turbulence velocities as felt by rotating rotorcraft blades is developed. Turbulence over a rotor blade is approximated by a series of radial shape functions. With this expansion, a stochastic state space model is formed where the system dynamics matrix and the controls matrix are periodic with a period equal to the rotor rotational speed and input to the plant is generated by independent white noise sources. In order to calculate the plant dynamics and control matrices an algorithm has been developed which computes the stochastic state space model by minimizing the square error between the actual atmospheric turbulence velocity vector and the approximate atmospheric turbulence velocity vector. The new model is drastically different from conventional rotorcraft atmospheric turbulence models owing to the fact that the statistics of atmospheric turbulence, which determine the state space model, are computed in the rotating blade reference frame as opposed to conventional rotorcraft atmospheric turbulence models which compute the statistics of atmospheric turbulence at the center of gravity of the aircraft. Conventional atmospheric turbulence models can be improved upon for many flight conditions which rotorcraft routinely encounter. The model presented in this paper is developed from first principles and an example is provided to illustrate the type of information which can be extracted from this new approach to modeling atmospheric turbulence which a rotating blade experiences. Author

A91-17282
HELICOPTER PARAMETER IDENTIFICATION USING A TRAINED MULTI-PERCEPTRON NEURAL NETWORK
QUANG M. LAM, LOUIS P. PELOSI, RICHARD H. CLAPP (Synetics Corp., Command and Control Div., Warminster, PA), and MOSHE KAM (Drexel University, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1017-1033. refs
Copyright

A trained multi-perceptron is used to perform helicopter parameter identification. A learning algorithm based on error back-propagation is adapted in order to copy an input-output mapping into the network, which then realizes a parameter identification algorithm. The resulting architecture is used to reconstruct the stability and control derivatives of a UH-60A helicopter model, using simulated data at hover mode. The simulated data is generated with various system noise intensities to mimic realistic true helicopter data. The studied neural network identifier is found to be useful to the estimation task for the following reasons: (1) it does not require a priori information; (2) it is relatively insensitive to system uncertainties (e.g., noise levels, model structures); (3) it demonstrates high relaxation on input designs and output samples; and (4) it has self-learning ability to adjust the parameter estimate vector to compensate for incorrect model structure selection and to assure the fidelity of the identified model in comparison with the 'true' system responses. Author

A91-17293
TESTING OF THE V-22 FLIGHT CONTROL SYSTEM
WALTER L. BALLAUER, JOHN R. LEET, JAMES MITCHELL, and DAVID R. ECK (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter

Society, 1990, p. 1147-1160.

The V-22 Flight Control System and means of testing prior to initial flight are discussed. It is pointed out that the hierarchical structure of the system and software design allows testing at multiple levels ensuring that all systems requirements are met. Testing focuses primarily on software verification, hardware-software integration, and system validation testing. The regression testing required to revalidate the flight critical system as changes are made during the flight development program is addressed. L.K.S.

A91-17294* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT INVESTIGATION OF THE EFFECT OF TAIL BOOM STRAKES ON HELICOPTER DIRECTIONAL CONTROL
HENRY L. KELLEY, CYNTHIA A. CROWELL (NASA, Langley Research Center; U.S. Army Aerostructures Directorate, Hampton, VA), KENNETH R. YENNI (NASA, Langley Research Center, Hampton, VA), and MICHAEL B. LANCE (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1161-1174. refs

A joint U.S. Army/NASA flight investigation was conducted utilizing an instrumented Bell 240B single-rotor helicopter to determine the effectiveness of horizontally-mounted tail boom strakes on directional controllability and tail rotor power required during low-speed, crosswind operating conditions. The purpose of the strakes was to separate airflow over the tail boom and change fuselage yawing moments in a direction to improve the yaw control margin and reduce tail rotor power required. Low-speed crosswind data were obtained in 5-knot increments at airspeeds of 0 knots to 35 knots and for 30 deg increments in wind azimuth from 0 to 330 deg. In right sideward flight at the most critical wind azimuth and airspeed (60 deg azimuth measured from the nose of the aircraft and 20 knots airspeed), the strakes improved the pedal margin by about 6 percent of total travel and reduced the tail rotor power required by 17 percent. The increase in yaw control and reduction in tail rotor power offered by the strakes can expand the operating envelope in terms of gross weight and altitude capability. No effects in forward flight were noted. Author

A91-17298* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
OBTAINING CONSISTENT MODELS OF HELICOPTER FLIGHT-DATA MEASUREMENT ERRORS USING KINEMATIC-COMPATIBILITY AND STATE-RECONSTRUCTION METHODS
JAY W. FLETCHER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1221-1232. Previously announced in STAR as N90-26799. refs

A new method was developed for application of Kalman Filter/Smoothers to post-flight processing of helicopter flight test dynamic measurements. This processing includes checking for kinematic compatibility among the measurements, identification of a measurement error model, and reconstruction of both measured and unmeasured time histories. Emphasis is placed on identification of a parametric measurement error model which is valid for a set of flight test data. This is facilitated through a new method of concatenating several maneuver time histories. The method also includes a model structure determination step which ensures that a physically realistic parameterization has been achieved. Application of the method to a set of BO-105 flight test data is illustrated. The resulting minimally parameterized error model is shown to characterize the measurement errors of the entire data set with very little variation in the parameter values. Reconstructed time histories are shown to have increased bandwidths and signal to noise ratios. Author

A91-17306* McDonnell-Douglas Helicopter Co., Mesa, AZ.
VALIDATION OF A FLIGHT SIMULATION MODEL OF THE AH-64 APACHE ATTACK HELICOPTER AGAINST FLIGHT TEST DATA
J. W. HARDING and S. M. BASS (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1309-1325. refs
(Contract NAS2-12913)

The FLYRT simulation model of the U.S. Army/McDonnell Douglas AH-64 Apache attack helicopter is validated against flight test data. The approach used for validation involves matching static trim attitudes and control positions and driving the model with measured control time histories to compare dynamic responses such as angular rates and normal acceleration. Flight test data is processed to determine kinematic consistency in the angular degrees of freedom. Modeling problems associated with aerodynamic interaction of the main rotor wake on the horizontal stabilator and engine response timing are identified. Appropriate model updates are made which result in good overall model correlation throughout the flight regime investigated. Author

A91-17427
PERFORMANCE ANALYSIS OF PNG LAWS FOR RANDOMLY MANEUVERING TARGETS
IN-JOONG HA, JONG-SUNG HUR, MYOUNG-SAM KO (Seoul National University, Republic of Korea), and TAEK-LYUL SONG (Agency for Defense Development, Taejon, Republic of Korea) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 26, Sept. 1990, p. 713-721. refs

The performance of the conventional proportional navigation guidance (PNG) law for a randomly maneuvering target is considered. By means of the Liapunov method, it is proved that an ideal missile guided by the conventional PNG law can always intercept a target which maneuvers with time-varying normal acceleration provided that the navigation constant is sufficiently large. Also proposed is a modified PNG (MPNG) law which seems to improve the performance of the conventional PNG law at the final phase of pursuit. Simulation results demonstrate that the MPNG law demands less missile acceleration at the final phase of pursuit than the conventional PNG law. I.E.

A91-17643#
PHYSICAL ASPECTS OF ROTOR BODY COUPLING IN STABILITY AND CONTROL
H. C. CURTISS, JR. (Princeton University, NJ) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 6 p.

The effects of rotor-body coupling on the response of a single-rotor helicopter to control inputs are examined. The nature of flap and lag coupling and physical sources of the interactions between the rotor and body are discussed. The linearized model of a helicopter used in this study has four fuselage degrees of freedom, two multiblade coordinates describing the flapping or tip path plane motion, and two multiblade lag coordinates. It is demonstrated that the flap and lag degrees of freedom have a significant effect on the control response characteristics of rotorcraft with the lag degrees of freedom having influence on the frequency response of a helicopter. V.T.

A91-17700*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT DYNAMICS RESEARCH FOR HIGHLY AGILE AIRCRAFT
LUAT T. NGUYEN (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Anaheim, CA, Sept. 25-28, 1989. 54 p. refs
(SAE PAPER 892235)

This paper highlights recent results of research conducted at the NASA Langley Research Center as part of a broad flight dynamics program aimed at developing technology that will enable

future combat aircraft to achieve greatly enhanced agility capability at subsonic combat conditions. Studies of advanced control concepts encompassing both propulsive and aerodynamic approaches are reviewed. Dynamic stall phenomena and their potential impact on maneuvering performance and stability are summarized. Finally, issues of mathematical modeling of complex aerodynamics occurring during rapid, large amplitude maneuvers are discussed. Author

A91-17990
NON-HOMOGENEOUS TRACK-INDUCED RESPONSE OF VEHICLES WITH NON-LINEAR SUSPENSION DURING VARIABLE VELOCITY RUNS
D. YADAV and K. E. KAPADIA (Indian Institute of Technology, Kanpur, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 143, Nov. 22, 1990, p. 51-64. refs
Copyright

The response characteristics evaluation of a vehicle with variable velocity over a rigid, nonhomogeneous track is presented. The vehicle suspension system includes nonlinearities in the spring and the damper. The effect of linkage dynamics is included in the study. The nonhomogeneous ground profile is expressed as the sum of a variable mean and a zero mean random unevenness. A Monte Carlo simulation approach is used for the solution of the problem. Response samples are generated to form an ensemble and processed to obtain the second order response statistics during landing and take-off, and thus study the effect of the track roughness on the response. Author

A91-18052
RESPONSE OF HANG GLIDERS TO CONTROL
GUIDO DE MATTEIS (Roma I, Universita, Rome, Italy) Aeronautical Journal (ISSN 0001-9240), vol. 94, Oct. 1990, p. 289-294. refs
Copyright

A general dynamic model of the hang glider is applied to the analysis of response to control. The transfer functions of the glider to the longitudinal and lateral controls are formulated and some significant results, in terms of frequency response are presented and discussed. The relevant effects of the unsteady aerodynamics on the dynamics of the system are shown and the characteristics of poor lateral control are confirmed as observed in flight. Author

A91-18067#
DESIGNS OF A GUST LOAD ALLEVIATION SYSTEM FOR A CANTILEVERED ELASTIC RECTANGULAR WING AND WIND-TUNNEL TESTS
ATSUSHI FUJIMORI and HIROBUMI OHTA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 441, 1990, p. 524-532. In Japanese, with abstract in English. refs

This paper describes designs for a gust load alleviation (GLA) system and its wind-tunnel tests. The objective is to verify the effectiveness of control system syntheses which are examined theoretically in active flutter suppression (AFS). Applying the syntheses to the GLA system of a cantilevered elastic rectangular wing, the first or the second order controllers can be constructed. It is shown in the wind-tunnel tests that the bending moment at the wing root is reduced to 66.2 percent of the control-off value at best by using a designed reduced-order controller. Furthermore, the robustness for the parameter perturbation of the plant is verified in the tests where the wind velocity is 50 percent higher than the designed wind velocity. Author

A91-19007#
THREE-DIMENSIONAL TRAJECTORY OPTIMIZATION FOR AIRCRAFT
ROBERT L. SCHULTZ (Honeywell, Inc., Minneapolis, MN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 936-943. refs
Copyright

A solution method for determining three-dimensional minimum-time aircraft trajectories for aircraft is described. The method is based on Euler-Lagrange optimization theory and energy state approximations. The optimal controls are found by either maximizing or minimizing a modified Hamiltonian. The starting extremum operation and the switching conditions from one extremum operation to the other are determined. The solution is computed by iteration on the two constant adjoint variables. The solution convergence, however, is sensitive to these parameters. A method based on the characteristics of the heading adjoint variable is used to reduce this sensitivity. A roll angle chattering solution, which occurs during the minimum power energy loss segment of the trajectory and causes computational problems, is removed by including a penalty on the roll angle magnitude in the performance criterion. A number of specific problems are then solved. Author

A91-19008#
INERTIAL ENERGY DISTRIBUTION ERROR CONTROL FOR OPTIMAL WIND-SHEAR PENETRATION
K. KRISHNAKUMAR and J. E. BAILEY (Alabama, University, Tuscaloosa) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 944-951. Previously cited in issue 09, p. 1293, Accession no. A89-25012. refs
Copyright

A91-19009#
TWO-TIME-SCALE LONGITUDINAL CONTROL OF AIRPLANES USING SINGULAR PERTURBATION
HASSAN K. KHALIL (Michigan State University, East Lansing) and FU-CHUANG CHEN Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 952-960. Previously cited in issue 21, p. 3493, Accession no. A88-50215. refs
(Contract NSF ECS-86-10714)
Copyright

A91-19010#
PROPOSAL AND FLIGHT EVALUATION OF A NEW PITCH-MODE DECOUPLING SYSTEM
MASAKI KOMODA (Tokyo Metropolitan Institute of Technology, Japan), NAGAKATU KAWAHATA (Nihon University, Chiba, Japan), YUKICHI TSUKANO, and TAKATSUGU ONO (National Aerospace Laboratory, Tokyo, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 961-968. refs
Copyright

A new pitch-mode decoupling system is proposed and evaluated by flight tests using an experimental airplane. In the proposed system, both speed stability and static stability are nullified by feedback of air speed and angle-of-attack variations into the elevator. Pitch stability is augmented through feedback of pitch attitude and its time rate into the elevator. The resulting system attains the same goal as the infinitely high gain 0-closure system, while requiring only a finite servo bandwidth. After pitch-loop closure, there remains an inherent control cross coupling, where air speed and flight-path angle responses to thrust input are unfavorably modified and thus produce possible speed excursions. A simple crossfeed of throttle command into attitude command solves the problem. Flight test results are included. Author

A91-19011#
MODEL FOLLOWING RECONFIGURABLE FLIGHT CONTROL SYSTEM FOR THE AFTI/F-16
W. D. MORSE (Sandia National Laboratories, Albuquerque, NM) and K. A. OSSMAN (Ohio State University, Columbus) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 969-976. Research supported by USAF. refs
Copyright

In the event of a control surface failure, the purpose of a reconfigurable flight control system is to redistribute and coordinate the control effort among the aircraft's remaining effective surfaces such that satisfactory flight performance is retained. In this paper, a model following reconfigurable flight control system designed for the AFTI/F-16 is discussed. The system utilizes an adaptive

proportional plus integral controller with gain adjustment based on errors between desired performance and actual performance. Stability analysis and simulation results are presented. Author

A91-19016*# City Coll. of the City Univ. of New York, NY.
EIGENSTRUCTURE ASSIGNMENT WITH GAIN SUPPRESSION USING EIGENVALUE AND EIGENVECTOR DERIVATIVES
KENNETH M. SOBEL (City College, New York), FREDERICK J. LALLMAN (NASA, Langley Research Center, Hampton, VA), and WANGLING YU Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1008-1013. Previously cited in issue 21, p. 3493, Accession no. A88-50206. refs
Copyright

A91-19291#
A GENERALIZED TECHNIQUE FOR INVERSE SIMULATION APPLIED TO AIRCRAFT FLIGHT CONTROL
R. A. HESS, C. GAO, and S. H. WANG (California, University, Davis) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0419) Copyright

An algorithm is presented which serves as an efficient inverse simulation tool for analyzing flight maneuvering. This generalized technique is essentially an integration algorithm, as opposed to current inverse simulation methods that require numerical time differentiation in their implementation. Inverse solutions are given for a large-amplitude aircraft maneuver and a nap-of-the-earth helicopter maneuver. It is shown that the technique can be applied to flight control problems in which the number of controls equal or exceed the number of constrained outputs. R.E.P.

A91-19293*# Georgia Inst. of Tech., Atlanta.
ON THE DESIGN OF DECOUPLING CONTROLLERS FOR ADVANCED ROTORCRAFT IN THE HOVER CASE
M. K. H. FAN (Georgia Institute of Technology, Atlanta), A. TITS, J. BARLOW, N. K. TSING (Maryland, University, College Park), M. TISCHLER, and M. TAKAHASHI (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(Contract NCA2-309; NSF CDR-88-03012; NSF DMC-84-51515)
(AIAA PAPER 91-0421) Copyright

A methodology for design of helicopter control systems is proposed that can account for various types of concurrent specifications: stability, decoupling between longitudinal and lateral motions, handling qualities, and physical limitations of the swashplate motions. This is achieved by synergistic use of analytical techniques (Q-parameterization of all stabilizing controllers, transfer function interpolation) and advanced numerical optimization techniques. The methodology is used to design a controller for the UH-60 helicopter in hover. Good results are achieved for decoupling and handling quality specifications. Author

A91-19316#
OPTIMUM TRANSITIONS IN CLIMB/CRUISE/DESCENT FOR HYPERSONIC CRUISE VEHICLES
H. G. KAUFFMAN, R. V. GRANDHI, W. L. HANKEY, and P. J. BELCHER (Wright State University, Dayton, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract F33615-87-C-1550)
(AIAA PAPER 91-0472) Copyright

A simple and efficient performance analysis method is developed for the evaluation of fixed endpoint flight-path optimization problems. A methodology based on the 'Energy Method' is derived for optimizing transitions between climb/cruise and cruise/descent for a hypersonic reconnaissance vehicle (Mach 6). Powered hypersonic flight produces some unique performance characteristics for which the methodology satisfies mission, flight, and vehicle related requirements and constraints. The transitions are evaluated for minimum fuel burned between end points. Results from a parametric study on transitional trajectories are presented to validate the methodology. Author

N91-13459 Stanford Univ., CA.
INTEGRATED AERODYNAMIC AND CONTROL SYSTEM DESIGN OF OBLIQUE WING AIRCRAFT Ph.D. Thesis
STEPHEN JAMES MORRIS 1990 270 p
Avail: Univ. Microfilms Order No. DA9024348

Improving the handling qualities of oblique wing aircraft is emphasized. This is accomplished by including aerodynamic configuration parameters as variables in the control system synthesis to provide additional degrees of freedom with which to further decouple the aircraft's response. Handling qualities are measured using a quadratic cost function identical to that considered in optimal control problems, but the controller architecture is not restricted to full state feedback. An optimization procedure is used to simultaneously solve for the aircraft configuration and control gains which maximize a handling qualities measure, while meeting imposed constraints on trim. In some designs, wing flexibility is also modeled and reduced order controllers are implemented. Oblique wing aircraft synthesized by this integrated design method show significant improvement in handling qualities when compared to the originally proposed closed loop aircraft. The integrated design synthesis method is then extended to show how handling qualities may be traded for other types of mission performance (drag, weight, etc.). Examples are presented which show how performance can be maximized while maintaining handling quality. Dissert. Abstr.

N91-13460*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
INTEGRATED FLIGHT-PROPULSION CONTROL CONCEPTS FOR SUPERSONIC TRANSPORT AIRPLANES
FRANK W. BURCHAM, JR., GLENN B. GILYARD, and PAUL A. GELHAUSEN Nov. 1990 18 p Presented at the Society of *Automotive Engineers (SAE), Inc. Aerotech Conference, Long* Beach, CA, 1-4 Oct. 1990 Prepared in cooperation with NASA-Ames Research Center, Moffett Field, CA
(NASA-TM-101728; H-1673; NAS 1.15:101728; SAE-901928)
Avail: NTIS HC/MF A03 CSCL 01/3

Integration of propulsion and flight control systems will provide significant performance improvements for supersonic transport airplanes. Increased engine thrust and reduced fuel consumption can be obtained by controlling engine stall margin as a function of flight and engine operating conditions. Improved inlet pressure recovery and decreased inlet drag can result from inlet control system integration. Using propulsion system forces and moments to augment the flight control system and airplane stability can reduce the flight control surface and tail size, weight, and drag. Special control modes may also be desirable for minimizing community noise and for emergency procedures. The overall impact of integrated controls on the takeoff gross weight for a generic high speed civil transport is presented. Author

N91-14325# National Aeronautical Establishment, Ottawa (Ontario).
WIND TUNNEL INVESTIGATION AND FLIGHT TESTS OF TAIL BUFFET ON THE CF-18 AIRCRAFT
B. H. K. LEE, D. BROWN, M. ZGELA, and D. POIREL *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 26 p Sep. 1990
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Investigations of tail buffet on the CF-18 were conducted at the National Aeronautical Establishment (NAE) and the Aerospace Engineering Test Establishment (AETE). Flow visualization of the vortex burst phenomenon was carried out in a low speed water tunnel using a modified 1/72 scaled plastic model. In wind tunnel tests, a rigid 6 percent model was used for measurements in the NAE 5 x 5 ft Trisonic Tunnel. Unsteady pressure measurements on the vertical fin were made by means of 24 fast response transducers on each surface. Results of the acceleration experienced by the fin are presented. The vortex flow structure was studied with the aid of a 49 pressure-sensor-rake mounted behind the fin. In addition to measuring steady pitot pressure values, to deduce pressure contours, unsteady pressure fluctuations were

obtained from 13 fast response transducers. The leading edge extension (LEX) was also instrumented with pressure orifices and fast response transducers. The investigation was carried out with LEX fences on and off to note their effect on tail buffet loads. Flight tests were conducted at AETE on a test aircraft with accelerometers installed on the vertical fins and horizontal stabilators and strain gauges mounted on the aft fuselage structures and fin root attachment stubs. Flight test data are presented showing the effectiveness of the LEX fence in reducing aft fuselage structural response to buffet loads. Author

N91-14326# McDonnell Aircraft Co., Saint Louis, MO.
A UNIFIED APPROACH TO BUFFET RESPONSE OF FIGHTER AIRCRAFT EMPENNAGE
M. A. FERMAN, S. R. PATEL, and N. H. ZIMMERMAN *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 18 p Sep. 1990

A unified approach was derived for predicting buffet response of fighter aircraft empennage operating in high angle of attack maneuvering conditions. Since the advent of high angle of attack flight using controlled vortex flows, incidences of severe structural stress, and in some cases, damages have resulted. This was pronounced on twin tailed aircraft, including McDonnell's F-15 and F/A-18 aircraft which required structural beef-ups to their empennage. Two concepts are shown for predicting buffet response of empennage. The first approach uses elastically scaled models in wind tunnel tests to provide full scale prediction. The second approach is based on calculations using measured pressure data from wind tunnel tests. The latter method is more versatile. Detailed applications are shown for the F/A-18 empennage, while other applications at McDonnell are noted. This work covers many years and is believed to be a mature approach. Author

N91-14328# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Institut fuer Experimentelle Stroemungsmechanik.
EXPERIMENTAL INVESTIGATION OF BUFFET ONSET AND PENETRATION ON A SUPERCRITICAL AIRFOIL AT TRANSONIC SPEEDS
E. STANEWSKY and D. BASLER (Holtronic G.m.b.H., Ottersberg, Germany, F.R.) *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 11 p Sep. 1990

An experimental investigation was carried out on the supercritical airfoil CAST 7/DOA1 to determine the influence of three parameters, Mach number, angle of attack and most of all Reynolds number, on the buffet process and especially on the shock oscillation frequency and amplitude. For this investigation, the model was equipped with regular pressure orifices, dynamic pressure transducers and hot-film sensors, the latter utilized to determine transition location and regions of separation. The flow field was observed by a holographic high-speed, real-time interferometer. The analysis of the results revealed that the buffet process is essentially driven by the interaction of the upper surface shock wave with the boundary layer, especially as it influences the development of the shock-induced separation bubble, and the resultant change in flow conditions at the airfoil trailing edge and that, within the domain of intensive buffet, the shock oscillation frequency decreases with Reynolds number while the amplitude increases. It was furthermore found that the amplitude of the shock oscillation, hence the magnitude of the change in the dynamic load on the airfoil, seems to be dependent on the airfoil geometry. Author

N91-14329# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Aeroelasticity.
EXPERIMENTAL INVESTIGATIONS OF BUFFET EXCITATION FORCES ON A LOW ASPECT RATIO TRAPEZOIDAL HALF WING IN INCOMPRESSIBLE FLOW
P. BUBLITZ and H. ZINGEL (Deutsche Airbus G.m.b.H., Bremen, Germany, F.R.) *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 19 p Sep. 1990

The problem of determining the steady and unsteady airloads is determined for swept wings of low aspect ratios at high incidences. Despite great progress in the field of computational fluid dynamics (CFD), this problem is not yet accessible to computer-supported methods, at least with respect to unsteady airloads. First, the information will be discussed which is necessary for buffeting prediction. The reasons for performing pressure measurements are outlined. Then, a brief description of the test set-up and instrumentation will be given. The steady and unsteady test results will be presented and their strong mutual interdependency will be demonstrated. The question as to whether it is possible to separate the unsteady pressures due to flow separation from those due to oscillatory motion of the model will be answered on the basis of experimental results. The usefulness of such investigations and their limitations with respect to the buffeting problem will be discussed. Author

N91-14330# Deutsche Airbus G.m.b.H., Bremen (Germany, F.R.).
EXPERIMENTAL INVESTIGATION AND SEMI-EMPIRICAL PREDICTION OF THE DYNAMIC RESPONSE OF A LOW-ASPECT-RATIO TRAPEZOIDAL WING DUE TO FLOW SEPARATION
H. ZINGEL *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 16 p Sep. 1990

The buffet response of a low-aspect-ratio trapezoidal half-wing model was measured in the low speed wind tunnel of the DLR-Research Center in Goettingen at different model natural frequencies of pitch and roll both separately and coupled and at different angles of incidence up to 40 degrees. On the basis of linear aeroelastic equations of motion and measured structural dynamic and unsteady aerodynamic input data, the buffet response was calculated and compared with the measurement. The comparison shows a satisfactory coincidence. Consequently the adopted way for the semi-empirical calculation of the buffet response proves to be practicable. Author

N91-14332# Bristol Univ. (England). Dept. of Aerospace Engineering.
THE FORWARD MOUNTED SPOILER AS A SOURCE OF BUFFET EXCITATION
P. G. MYERS and D. L. BIRDSALL *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 13 p Sep. 1990 Sponsored by Departmant of Trade and Industry, England

Tests were made with fixed transition at low Reynolds Numbers (usually 0.56 x 10(exp 6), based on chord) on a wing with a spoiler of length 8 percent chord hinged at 13 percent chord. Different classes of flow leading to differing spoiler performance have been identified. However signal analysis has shown that the non-dimensional frequency n(sub 1) can be used to correlate results from these classes of flow and that the peak frequencies will lie within a narrow band. Now n(sub 1) = fl(sub b)/V where f is the frequency, l(sub b) the length of separated flow from the spoiler free edge lying over the wing (in the case of a closed bubble, l(sub b) is the bubble length) and V the freestream velocity. Since n(sub 1) depends on l(sub b), a good idea of the nature of buffet excitation can be formed from an observation of the scale of separated flow lying over the wing. With one class of flow, there was no change in steady state lift following spoiler deployment, but the formation of a separation bubble over much of the wing upper surface led to a high level of buffet excitation. This underlines the difficulty of trying to deduce the fluctuating component of lift from a steady mean. Author

N91-14333# National Aerospace Lab., Amsterdam (Netherlands).
INVESTIGATION OF A SEMI-EMPIRICAL METHOD TO PREDICT LIMIT CYCLE OSCILLATIONS OF MODERN FIGHTER AIRCRAFT
J. J. MEIJER and R. J. ZWAAN *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 8 p Sep. 1990
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Requirements of modern fighter aircraft to operate with high maneuverability in the transonic speed regime may lead under certain conditions to limit cycle oscillations (LCO), produced by a structural/aerodynamic interaction. Conditions of transonic LCO are moderate angel of attack and Mach numbers ranging from 0.9 to 1.1. An analysis of steady wind tunnel data, obtained for a fighter type aircraft in a typical configuration, has indicated that shock-induced separation plays a dominant role. A semi-empirical prediction method is presented which makes use of these steady data, and some results are shown. Possibilities are discussed to extend the method to the use of unsteady wind tunnel data. Author

N91-14335*# General Dynamics Corp., Fort Worth, TX.
PREDICTIONS OF F-111 TACT AIRCRAFT BUFFET RESPONSE
ATLEE M. CUNNINGHAM, JR. and CHARLES F. COE (Coe Engineering, Inc., Los Altos, CA.) *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 16 p Sep. 1990
(Contract NAS2-11420)
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

A summary is presented for the prediction method development and correlations of predicted response with flight test measurements. The prediction method was based on refinements to the method described by Cunningham. One improvement made use of direct time integration of the correlated fluctuating pressure data to obtain buffet excitation for the various modes of interest. Another improvement incorporated a hybrid technique for scaling measured wind tunnel damping data to full-scale for the modes of interest. A third improvement made use of the diagonalized form of the fully coupled equations of motion. Finally, a mechanism was described for explaining an apparent coupling between the aircraft wing torsion modes and shock induced trailing edge separation that led to very high wing motion on the aircraft that was not observed on the wind tunnel model. Author

N91-14336# National Aeronautical Establishment, Ottawa (Ontario).
THE EFFECT OF WING PLANFORM ON LOW SPEED BUFFET
S. J. ZAN and D. J. MAULL (Cambridge Univ., England) *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 15 p Sep. 1990 Sponsored by Department of Trade and Industry, England
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A parametric experimental investigation into low speed buffet is presented. The influence of wing generalized mass, reduced frequency, aspect ratio, dynamic pressure and wing sweep on the buffet excitation parameter, the square root of nG(n), was studied for a simple wing model with sharp leading and trailing edges. The investigation was limited to buffeting response in the fundamental bending mode. The angle of incidence range for the experiments was 0 to 40 deg, however the paper will concentrate on results at 10 deg incidence (near stall) and at 30 deg incidence. The influence of aspect ratio on the buffet excitation parameter was found to be significant at high incidences at values of reduced frequency below those common for subsonic flight. Author

N91-14337# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NEW METHOD TO DETERMINE IN WIND TUNNEL THE BUFFETING FORCES
ROGER DESTUYNDER and ROLAND BARREAU (Aerospatiale, Toulouse, France) *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 16 p Sep. 1990 In FRENCH; ENGLISH Summary
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Among the usual criteria used to qualify the airplane buffet onset, it is classical to use the acceleration values measured at the pilot seat and limited at + or - 0.2g. This acceleration is the result of two excitation systems. The first one, due to the external forces, is created by the random unsteady field of pressure on the airplane and acting in a large frequency range. The second excitation is due to the induced pressures coming from the airplane motions and characterizing principally the eigen modes of the structure. It seems interesting to separate the two pressure fields to improve the buffet knowledge not only to have the correct buffet onset forces but also to obtain the forces distribution. For this target a closed loop system using a parameter of the wing (unsteady bending moment or accelerometers) permits in wind tunnel to reduce the wing motion introducing damping forces, in the model with the help of actuator. It is necessary to translate these results to the aircraft, the static deformation of the model and aircraft being similar. In a second phase, always under buffet conditions, sinusoidal excitations are applied on the wind tunnel model, giving a field of pressure uncorrelated with the buffeting pressure. In this manner the possibility of extraction, using an FFT, is given for the induced complex pressure and forces. Some examples are given. Author

N91-14338# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
COUPLED AERODYNAMIC LOADS DUE TO UNSTEADY STALL ON A LARGE ASPECT RATIO WING OSCILLATING AT GREAT AMPLITUDE [FORCES AERODYNAMIQUES COUPLEES DUES AU DECROCHAGE INSTATIONNAIRE SUR UNE AILE DE GRAND ALLONGEMENT OSCILLANT A GRANDE AMPLITUDE]
J.-J. COSTES and D. PETOT *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 15 p Sep. 1990 In FRENCH; ENGLISH Summary
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Experimental results which were obtained on a rectangular wing oscillating in pitch around the quarter chord line are presented. Normal flow as well as skewed flow cases were investigated. The comparison with a simple theory used in helicopter applications showed the influence of the tip wing vortex and the importance, in the skewed flow case, of the component of the wind velocity directed along the wing span. Author

N91-14339# Lockheed Missiles and Space Co., Sunnyvale, CA.
UNSTEADY SEPARATED FLOW PHENOMENA CAUSING SELF-EXCITED STRUCTURAL OSCILLATIONS
L. E. ERICSSON *In* AGARD, Aircraft Dynamic Loads Due to Flow Separation 16 p Sep. 1990
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Because of steadily increasing performance demands both aircraft and missiles operate at high angles of attack where separated flow often has a dominant influence on especially the unsteady aerodynamics. The penetration of the buffet boundary usually changes the structural response from the buffet-type to the self-excited type. This transfer occurs when the structural response starts interacting with the unsteady flow separation, generating negative aerodynamic damping. Separated flow aerodynamics are usually very nonlinear, and the self-excited response frequently takes the form of a limit-cycle oscillation. Author

N91-14353*# Calspan-State Univ. of New York Joint Venture, Buffalo, NY.
INTERACTION OF FEEL SYSTEM AND FLIGHT CONTROL SYSTEM DYNAMICS ON LATERAL FLYING QUALITIES Final Report
R. E. BAILEY and L. H. KNOTTS Dec. 1990 391 p
(Contract NASA ORDER A-43049-C)
(NASA-CR-179445; H-1584; NAS 1.26:179445;
CALSPAN-7205-26) Avail: NTIS HC/MF A17 CSCL 01/3

An experimental investigation of the influence of lateral feel system characteristics on fighter aircraft roll flying qualities was conducted using the variable stability USAF NT-33. Forty-two evaluation flights were flown by three engineering test pilots. The investigation utilized the power approach, visual landing task and up-and-away tasks including formation, gun tracking, and computer-generated compensatory attitude tracking tasks displayed on the Head-Up Display. Experimental variations included the feel system frequency, force-deflection gradient, control system command type (force or position input command), aircraft roll mode time constant, control system prefilter frequency, and control system time delay. The primary data were task performance records and evaluation pilot comments and ratings using the Cooper-Harper scale. The data highlight the unique and powerful effect of the feel system of flying qualities. The data show that the feel system is not 'equivalent' in flying qualities influence to analogous control system elements. A lower limit of allowable feel system frequency appears warranted to ensure good lateral flying qualities. Flying qualities criteria should most properly treat the feel system dynamic influence separately from the control system, since the input and output of this dynamic element is apparent to the pilot and thus, does not produce a 'hidden' effect. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A91-17272
CHAMP - A HELICOPTER/VTOL FLIGHT MODEL FOR INTEGRATED OPERATIONAL ANALYSIS
SALLY LA FORGE, JAMES JENNINGS, and ALBERT ZOBRIST (Rand Corp., Santa Monica, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 899-903.
Copyright

This paper briefly describes the building blocks of the system used at RAND for operational analysis of Military Helicopters and Fixed Wing aircraft. The focus is on the CHAMP (CAGIS Helicopter Agility-Maneuverability Program) and its interface with the other models. CHAMP is a subset of the flight planner which uses geographic terrain with trees and other map information, and describes the agility and maneuverability of a selected helicopter. Data representing the flight characteristics of the selected helicopter is input in tables as a function of airspeed. The operator 'flies' the helicopter over the terrain developing a flight path which can then be analyzed for line-of-sight with threats, clutter, etc. The flight path is then analyzed by RJARS to determine the engagement and the probability of kill. Author

A91-17274
TACTS - HELICOPTER AIR COMBAT TRAINING SYSTEM OF THE FUTURE
BERNARD A. WUNDER (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 911-919.
Copyright

The Navy has developed a Tactical Aircrew Combat Training System for training fixed- and rotary-wing aircrews in live-flight, weapon-simulated air combat. Increasing numbers of helicopter types and associated weapon systems are being integrated into this training system although it was designed primarily for the fixed-wing aircraft. Descriptions of the system hardware and software are presented along with discussions of the various modes of training in air-to-air combat, no-drop weapon simulations, and electronic warfare. Examples of system displays from an actual air combat mission with two helicopters engaging two fixed-wing aircraft are used to demonstrate the capabilities of the system and the many training options available to the aircrews. Possible engineering applications for using the aircraft data recorded by the system are introduced. This paper concludes with a brief outline of future developments underway for increasing the capabilities of the system. Author

A91-17286
HELIPORT/VERTIPORT DEVELOPMENT
FRANK L. JENSEN, JR. (Helicopter Association International, Alexandria, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1057-1062.
Copyright

Heliports, i.e., designated areas from which to operate helicopters, have been the pacing or limiting factor in helicopter growth for decades. This paper discusses the history of Heliport/Vertiport Development, and describes some successful efforts by both government and private sector. Author

A91-17564*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED EXPERIMENTAL TECHNIQUES FOR TRANSONIC TESTING
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 28 p. refs

Problems common to wind tunnels, including low Reynolds numbers, wall interference, support interference, and flow unsteadiness are discussed, and it is noted that with increasing aircraft size, existing transonic tunnels are becoming more inadequate in terms of their Reynolds-number capability. Problems attributed to scale effect are covered, and techniques for increasing Reynolds number are presented. These include operating with a heavy gas or a mixture of gases, increasing the operating pressure in the tunnel, increasing the size of the model, and/or reducing the test temperature. Acceptable levels of flow unsteadiness are reviewed, along with the problems associated with the flow over wind-tunnel models influenced by flow unsteadiness. Sources of flow unsteadiness present in a continuous transonic tunnel driven by a compressor or a fan are listed, and rules for ensuring low levels of flow unsteadiness are given. V.T.

A91-17565*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC WIND TUNNELS. I
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 34 p. refs

The basic principles of cryogenic wind-tunnel operation are presented, and a typical cryogenic wind tunnel is described. Low-speed cryogenic wind tunnels are considered, along with some experiments conducted in these tunnels. Focus is placed on real-gas effects including condensation and thermal and caloric imperfections. The operating limits set by the saturation boundaries of nitrogen and air are analyzed, and the consequences of thermal and caloric imperfections on both isentropic and normal-shock flow in nitrogen are considered. The extension of analytical real-gas studies, including both laminar and turbulent boundary layers is covered. It is concluded that the deviation of the nitrogen

boundary-layer parameters from their ideal-gas values are small, and that large real-gas effects will not be a factor in cryogenic tunnel simulation of the complex flows met in flight. V.T.

A91-17566*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC WIND TUNNELS. II
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 24 p. refs

The application of the cryogenic concept to various types of tunnels including Ludwieg tube tunnel, Evans clean tunnel, blowdown, induced-flow, and continuous-flow fan-driven tunnels is discussed. Benefits related to construction and operating costs are covered, along with benefits related to new testing capabilities. It is noted that cooling the test gas to very low temperatures increases Reynolds number by more than a factor of seven. From the energy standpoint, ambient-temperature fan-driven closed-return tunnels are considered to be the most efficient type of tunnel, while a large reduction in the required tunnel stagnation pressure can be achieved through cryogenic operation. Operating envelopes for three modes of operation for a cryogenic transonic pressure tunnel with a 2.5 by 2.5 test section are outlined. A computer program for calculating flow parameters and power requirements for wind tunnels with operating temperatures from saturation to above ambient is highlighted. V.T.

A91-17567*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC WIND TUNNELS. III
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 58 p. refs

Specific problems pertaining to cryogenic wind tunnels, including LN(2) injection, GN(2) exhaust, thermal insulation, and automatic control are discussed. Thermal and other physical properties of materials employed in these tunnels, properties of cryogenic fluids, storage and transfer of liquid nitrogen, strength and toughness of metals and nonmetals at low temperatures, and material procurement and qualify control are considered. Safety concerns with cryogenic tunnels are covered, and models for cryogenic wind tunnels are presented, along with descriptions of major cryogenic wind-tunnel facilities the United States, Europe, and Japan. Problems common to wind tunnels, such as low Reynolds number, wall and support interference, and flow unsteadiness are outlined. V.T.

A91-17568*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TYPICAL TESTING EXPERIENCE IN CRYOGENIC WIND TUNNELS
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 32 p. refs

Airfoil testing as a major activity of many wind tunnels is considered, and emphasis is placed on airfoil testing with sidewall boundary-layer removal, oscillating airfoil testing, and three-dimensional wake topology. Buffeting as the structural response of an aircraft or test model to the aerodynamic excitation produced by separated flows is analyzed, as well as flutter problems and testing techniques. Strain-gage balance studies, optical methods and visualization techniques, and fluid mechanics are examined. Focus is placed on a two-spot laser as a boundary-layer probe, hot-film gages, fluctuating-pressure measurements, skin-friction balance, and nonadiabatic airfoil testing. Boattail afterbody pressure tests are covered, and Space Shuttle Orbiter base drag and launch configuration are discussed. V.T.

A91-17569*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADAPTIVE WALL TESTING SECTIONS (AWTS)
STEPHEN W. D. WOLF and ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 59 p. refs

The lecture starts with conventional techniques of minimizing wall interference and explains the principle of wall streamlining. The history of AWTS development is highlighted, along with the benefits of wall streamlining, including minimized boundary interference, increased model size, reduced tunnel drive power, noise, and volume, as well as multiple flow field simulations to be performed using one test section. AWTS-associated problems coming from the need to adjust the test-section boundaries for each test condition are assessed, along with the requirements of a boundary-adjustment strategy. Examples of two- and three-dimensional test sections are presented, and attention is focused on residual interference and the effects of compressibility and model lift on flexible-wall contours. V.T.

A91-17570*# Old Dominion Univ., Norfolk, VA.
MAGNETIC SUSPENSION AND BALANCE SYSTEMS (MSBSS)
COLIN P. BRITCHER (Old Dominion University, Norfolk, VA) and ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 43 p. refs

The problems of wind tunnel testing are outlined, with attention given to the problems caused by mechanical support systems, such as support interference, dynamic-testing restrictions, and low productivity. The basic principles of magnetic suspension are highlighted, along with the history of magnetic suspension and balance systems. Roll control, size limitations, high angle of attack, reliability, position sensing, and calibration are discussed among the problems and limitations of the existing magnetic suspension and balance systems. Examples of the existing systems are presented, and design studies for future systems are outlined. Problems specific to large-scale magnetic suspension and balance systems, such as high model loads, requirements for high-power electromagnets, high-capacity power supplies, highly sophisticated control systems and position sensors, and high costs are assessed. V.T.

A91-17571*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED EXPERIMENTAL TECHNIQUES FOR TRANSONIC WIND TUNNELS - FINAL LECTURE
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) National Defense Academy, Advanced Experimental Techniques for Transonic Wind Tunnels Meeting, Yokosuka, Japan, Oct. 12-23, 1987, Paper. 23 p.

A philosophy of experimental techniques is presented, suggesting that in order to be successful, one should like what one does, have the right tools, stick to the job, avoid diversions, work hard, interact with people, be informed, keep it simple, be self sufficient, and strive for perfection. Sources of information, such as bibliographies, newsletters, technical reports, and technical contacts and meetings are recommended. It is pointed out that adaptive-wall test sections eliminate or reduce wall interference effects, and magnetic suspension and balance systems eliminate support-interference effects, while the problem of flow quality remains with all wind tunnels. It is predicted that in the future it will be possible to obtain wind tunnel results at the proper Reynolds number, and the effects of flow unsteadiness, wall interference, and support interference will be eliminated or greatly reduced. V.T.

A91-17645#
V-22 GOVERNMENT TEST PILOT TRAINER PROGRAM OVERVIEW
JOHN D. MCGRILLIS and W. RUSTY LOWRY (U.S. Navy, Naval

Air Test Center, Patuxent River, MD) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 10 p. Research sponsored by the U.S. Navy.

The V-22 Government Test Pilot Trainer (GTPT) was developed to train government developmental and operational test pilots in as realistic an environment as possible. The GTPT is the first simulator to use the generic hardware and software of the Naval Air Test Center's manned flight simulator (MFS). The MFS uses a modular simulation design which allows various simulator cockpits to be switched in and out of any one or two engineering work stations, a 40 foot diameter fixed base dome, or a six degree of freedom motion base. The GTPT was developed to use these assets for V-22 government pilot training. This report presents an overview of the MFS facility, the V-22 GTPT simulator, and the training accomplished using the simulator. Author

A91-18071#
CHARACTERISTICS OF A CRYOGENIC WIND TUNNEL AT NATIONAL DEFENSE ACADEMY. II - TUNNEL CHARACTERISTICS AT AMBIENT AND CRYOGENIC TEMPERATURES
YUTAKA YAMAGUCHI, HIDEKI KABA, NOBUMITSU KURIBAYASHI, and YASUO NAKAUCHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 441, 1990, p. 559-565. In Japanese, with abstract in English. refs

As a result of previous operational experience with the high-speed cryogenic tunnel at National Defense Academy (NDA), its original manual control systems were partially modified and a limited automatic control capability was added. Though this modification was intended to improve the steady-state operation, the control accuracy of both of the steady and transient operations was greatly improved compared with that of the previous manual controls. Preliminary tunnel calibration tests were performed at both ambient and cryogenic temperatures, and the results indicate that the NDA cryogenic tunnel satisfies the assigned specifications and has sufficient potential to perform basic airfoil testings in a cryogenic temperature range. Author

A91-18264#
SYNCHRONIZATION AND TIME TAGGING IN DISTRIBUTED REAL TIME SIMULATION
AMNON KATZ, DANIEL M. ALLEN, and JOSEPH S. DICKSON (McDonnell Douglas Helicopter Co., Mesa, AZ) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 846-848. Previously cited in issue 21, p. 3278, Accession no. A89-48408.
Copyright

A91-19123#
THE APPLICATION OF NUMERICAL TECHNIQUES TO MODEL THE RESPONSE AND INTEGRATION OF THERMAL SENSORS IN WIND TUNNEL MODELS
JAMES R. HAYES and ALBERT A. ROUGEUX (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p.
(AIAA PAPER 91-0063)

The proper instrumentation of heat transfer test articles and the reduction of data obtained from them depends on a thorough understanding of the thermal models involved. Every heat transfer gage is designed upon some thermal model which is used to reduce it's output signal to incident heat flux. When a gage is installed in a test article the surrounding structure and aerothermal environment can cause unexpected internal conduction patterns which invalidate this basic thermal model. This results in reduction errors and data that is difficult to interpret. This paper discusses the use of two-dimensional conduction and inverse conduction codes for modeling basic gage response characteristics and the effects of thermal environment and installation design. It is shown that reliable response characteristics can be obtained with these codes which can be applied during the test article design process. Author

A91-19129*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A SYSTEM FOR TESTING AIRDATA PROBES AT HIGH ANGLES OF ATTACK USING A GROUND VEHICLE
ROBERT J. GEENEN, BRYAN J. MOULTON, and EDWARD A. HAERING, JR. (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p.
(AIAA PAPER 91-0088) Copyright

A system to calibrate airdata probes at angles of attack between 0 and 90 deg was developed and tested at the NASA Ames Dryden Flight Research Facility. This system used a test fixture mounted to the roof of a ground vehicle and included an onboard instrumentation and data acquisition system for measuring pressures and flow angles. The data could be easily transferred to the facility mainframe computer for further analysis. The system was designed to provide convenient and inexpensive airdata probe calibrations for projects which require airdata at high angles of attack, such as the F-18 High Alpha Research Program. This type of probe was tested to 90 deg angle of attack in a wind tunnel and using the ground vehicle system. The results of both tests are in close agreement. An airdata probe with a swiveling pilot-static tube was also calibrated with the ground vehicle system. This paper presents the results of these tests and gives a detailed description of the test system. Author

A91-19278#
WIND TUNNEL SUPPORT SYSTEM EFFECTS ON A FIGHTER AIRCRAFT MODEL AT MACH NUMBERS FROM 0.6 TO 2.0
DAVID G. WHITBY (Calspan Corp.; USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(AIAA PAPER 91-0396)

A wind tunnel investigation was conducted using a fighter aircraft model with various sting and blade support system arrangements to evaluate the effects of the model support system on total body and tail longitudinal force and moment data. Total aerodynamic force and moment data were determined from corrected strain gage balance-measured loads. Tail loads were obtained by subtracting tail-off from tail-on data. Data at free-stream Mach numbers from 0.6 to 2.0 and model angles of attack from -2 to 8 deg were examined. The analysis indicates a significant change in total-body and tail force coefficients in the presence of various support system configurations. The upper blade tends to decrease drag, lift, and pitching-moment coefficients, while the lower blade generally increases these coefficients. The influence of the sting on aerodynamic coefficients is a function of Mach number and angle of attack. A correction methodology using sting/blade 'tares' is proposed and evaluated. The evaluation shows that support system interference can be appreciably removed from total body and tail force and moment coefficient data using sting/blade 'tares'. However, some, perhaps nonlinear, effects remain. Author

A91-19279#
THE 10CM X 10CM MAGNETIC SUSPENSION AND BALANCE SYSTEM AT THE NATIONAL AEROSPACE LABORATORY
HIDEO SAWADA, HIROSHI KANDA, and HISASHI SUENAGA (National Aerospace Laboratory, Chofu, Japan) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0397) Copyright

The NAL 10 x 10-cm magnetic suspension and balance system is described. This system has three special features: its coil configuration, the model-position sensing system, and the way of controlling the model position. The measured magnetic-field intensity distributions show that the magnetic field is controlled by the currents passing through the coils (as expected by the plane magnetic circuit model), but the magnitude of the intensity is about half as much as expected. The region of controllable field is limited to the center of the test section. The calibration test results for the model-position sensing system are compared with the analytical ones and show the measured x, z and theta are good but y, phi, and psi are poor in accuracy. The way of controlling the model

position is to keep the relative model position constant with respect to the sensing system position. Then the model suspended can be changed in position over the wide range by changing the system position by this control method. Author

A91-19280#
VANE SUPPORT SYSTEM (VSS) - A NEW GENERATION WIND TUNNEL MODEL SUPPORT SYSTEM
STAN A. GRIFFIN, RICHARD S. CROOKS, and PHILLIP J. MOLE (General Dynamics Corp., Convair Div., San Diego, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0398) Copyright

Various sting systems are utilized, including blades/struts in combination with the internal strain gaged balance, in the current method of supporting models in a wind tunnel. A new method is proposed which involves removing the sting and supporting the model by attaching it to both ends of the balance. In this concept a two-shell balance is utilized where the inner rod (nonmetric) is the center core of the balance. In the example of the VSSEB (external balance), the summation of the load cells provides model forces and moments, and the internal balance is eliminated. The outer shell is the metric portion of the balance and is the model attachment. VSS is a support system that is almost free of flow disturbance, removes model distortion, and has unlimited angle of attack. It is shown that the VSS can have application to a number of testing scenarios where conventional approaches have limited use. R.E.P.

A91-19281*# Vigyan Research Associates, Inc., Hampton, VA.
AN EXPERIMENTAL STUDY OF WALL ADAPTATION AND INTERFERENCE ASSESSMENT USING CAUCHY INTEGRAL FORMULA
A. V. MURTHY (Vigyan Research Associates, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(Contract NAS1-18585)
(AIAA PAPER 91-0399) Copyright

This paper summarizes the results of an experimental study of combined wall adaptation and residual interference assessment using the Cauchy integral formula. The experiments were conducted on a supercritical airfoil model in the Langley 0.3-m Transonic Cryogenic Tunnel solid flexible wall test section. The ratio of model chord to test section height was about 0.7. The method worked satisfactorily in reducing the blockage interference and demonstrated the primary requirement for correcting for the blockage effects at high model incidences to correctly determine high lift characteristics. The studies show that the method has potential for reducing the residual interference to considerably low levels. However, corrections to blockage and upwash velocities gradients may still be required for the final adapted wall shapes. Author

A91-19282#
COMPUTATIONAL IMPROVEMENT OF INTERFERENCE AND ITERATIVE FUNCTIONS IN ADAPTIVE WALL WIND TUNNEL TESTING
C. F. LO and N. ULBRICH (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0400) Copyright

Adaptive wall wind tunnel testing is based on interference and iterative functions. These functions require velocity measurements on interfaces in the tunnel. Two computational improvements have been introduced successfully to these functions to reduce calculation time. Euler-MacLaurin's summation formula has been applied to calculate slowly converging infinite series which appear in interference and iterative functions. Interference and iterative functions require numerical integration which has been expressed as a matrix multiplication. A matrix containing measurement independent coefficients is multiplied by a vector depending on interface measurements. Integration by matrix multiplication has significantly reduced the calculation time as interference and iterative functions are applied. Both improvements have made the online operation of interference and iterative functions in adaptive wall wind tunnel testing more effective. Author

A91-19356*# Queensland Univ., Saint Lucia (Australia).
A DRAG MEASUREMENT TECHNIQUE FOR FREE PISTON SHOCK TUNNELS
S. R. SANDERSON, J. M. SIMMONS (Queensland, University, Brisbane, Australia), and S. L. TUTTLE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research supported by the Australian Research Council. refs
(Contract NAGW-674)
(AIAA PAPER 91-0549) Copyright

A new technique is described for measuring drag with 100-microsecond rise time on a nonlifting model in a free piston shock tunnel. The technique involves interpretation of the stress waves propagating within the model and its support. A finite element representation and spectral methods are used to obtain a mean square optimal estimate of the time history of the aerodynamic loading. Thus, drag is measured instantaneously and the previous restriction caused by the mechanical time constant of balances is overcome. The effectiveness of the balance is demonstrated by measuring the drag on cones with 5 and 15 deg semi-vertex angles in nominally Mach 5.6 flow with stagnation enthalpies from 2.6 to 33 MJ/kg. Author

A91-19400#
WIND TUNNEL MODEL COMPUTER CONTROL AT AEDC
R. F. LAUER, JR. and M. R. CRAWFORD (Calspan Corp.; USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0657) Copyright

Computer control of wind tunnel models has been done at the Arnold Engineering Development Center (AEDC) for many years. With improvements in computers and control systems over recent years this capability has been continually upgraded. At present it is possible to control simultaneously several independent model mechanisms to set exactly a specific set of interacting dependent variables. The approach taken in accomplishing this task is described using an example inlet performance model with four interacting flows and actuated flowmeters. Author

A91-19656
WIND TUNNEL COMPUTER CONTROL SYSTEM AND INSTRUMENTATION
DAVID M. NELSON (FluiDyne Engineering Corp., Minneapolis, MN) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 87-101.
Copyright

A state of the art digital control system design was applied to controlling both injector-driven closed circuit and blowdown wind tunnels. The high performance computer control system provides fast startup of wind tunnels to precise stable Mach numbers and flow conditions, and provides high accuracy model support control. The description includes the hardware configuration, instrumentation, safety considerations, control strategies and examples of performance of a transonic injector driven wind tunnel in Sweden and a trisonic blowdown wind tunnel in Japan. Author

A91-19659*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A VOICE-ACTUATED WIND TUNNEL MODEL LEAK CHECKING SYSTEM
WILLIAM E. LARSON (NASA, Langley Research Center, Hampton, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 123-128.

A computer program has been developed that improves the efficiency of wind tunnel model leak checking. The program uses a voice recognition unit to relay a technician's commands to the

computer. The computer, after receiving a command, can respond to the technician via a voice response unit. Information about the model pressure orifice being checked is displayed on a gas-plasma terminal. On command, the program records up to 30 seconds of pressure data. After the recording is complete, the raw data and a straight line fit of the data are plotted on the terminal. This allows the technician to make a decision on the integrity of the orifice being checked. All results of the leak check program are stored in a database file that can be listed on the line printer for record keeping purposes or displayed on the terminal to help the technician find unchecked orifices. This program allows one technician to check a model for leaks instead of the two or three previously required. Author

A91-19661*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE AUTOMATION OF AN INLET MASS FLOW CONTROL SYSTEM
FRANK SUPPLEE, PING TCHENG (NASA, Langley Research Center, Hampton, VA), and MICHAEL WEISENBORN IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 165-176.

The automation of a closed-loop computer controlled system for the inlet mass flow system (IMFS) developed for a wind tunnel facility at Langley Research Center is presented. This new PC based control system is intended to replace the manual control system presently in use in order to fully automate the plug positioning of the IMFS during wind tunnel testing. Provision is also made for communication between the PC and a host-computer in order to allow total animation of the plug positioning and data acquisition during the complete sequence of predetermined plug locations. As extensive running time is programmed for the IMFS, this new automated system will save both manpower and tunnel running time. R.E.P.

A91-19668*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN AIRFOIL PITCH APPARATUS-MODELING AND CONTROL DESIGN
DANIEL R. ANDREWS (NASA, Ames Research Center, Moffett Field, CA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 223-232. Previously announced in STAR as N89-20386. refs

The study of dynamic stall of rapidly pitching airfoils is being conducted at NASA Ames Research Center. Understanding this physical phenomenon will aid in improving the maneuverability of fighter aircraft as well as civilian aircraft. A wind tunnel device which can linearly pitch and control an airfoil with rapid dynamic reponse is needed for such tests. To develop a mechanism capable of high accelerations, an accurate model and control system is created. The model contains mathematical representations of the mechanical system, including mass, spring, and damping characteristics for each structural element, as well as coulomb friction and servovalve saturation. Electrical components, both digital and analog, linear and nonlinear, are simulated. The implementation of such a high-performance system requires detailed control design as well as state-of-the-art components. This paper describes the system model, states the system requirements, and presents results of its theoretical performance which maximizes the structural and hydraulic aspects of this system. Author

A91-19670
ADVANCES IN THE DEVELOPMENT OF EXTERNAL 6-COMPONENT WINDTUNNEL BALANCES
TIMM PREUSSER (Carl Schenck AG, Darmstadt, Federal Republic of Germany) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 251-259.

A review is presented on measuring technology that has led to a decisive change in the construction of external wind tunnel balances through the introduction of high performance master load cells, and through the replacement of mechanical force and moment separation by mathematical, computer aided separation. To further emphasize these changes, the definition of 12 essential requirements to wind tunnel balances are then catalogued. Detailed descriptions of new developments are provided, including that of a combined platform and pyramidal balance built into one single system. R.E.P.

A91-19674#
DATA ACQUISITION SYSTEM DEVELOPMENT FOR THE NASA-LANGLEY TRANSONIC DYNAMICS TUNNEL
JOHN A. IACOBUCCI (Wyle Laboratories, Hampton, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 305-313.

The data acquisition system development process for the NASA Langley Transonic Dynamics Tunnel (TDT) has been simplified by a structured top-down design technique to integrate various types of equipment and to satisfy CPU time demanding requirements and to introduce innovative software and hardware. A summary of the major requirements for TDT include a multiple facility support with facility isolation, a multiple CPU, the number of channels (128 channels of analog input are required), user program control, digital data support, and continual data archiving. The structured top-down design approach breaks down the system into individual functions until the basic functional level of the system is reached. Thus a very complicated system can be described more simply as a group of more easily comprehended tasks. R.E.P.

A91-19691
GRUMMAN'S REAL TIME TELEMETRY PROCESSING SYSTEM
C. SCHIANO (Grumman Data Systems, Woodbury, NY) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 607-612.

Systems features and capabilities for the Grumman Telemetry Processing System (TPS) are discussed. It is noted that the system which has been operating and supporting flight testing of military aircraft since 1970 has undergone four major upgrades. The TPS configuration, CAE integration, external processing system, and systems features are diagrammed. It is noted that the system can support up to five test articles in real time concurrently and that data is received via both low and high-speed telemetry links into a common data acquisitions subsystem. The data acquisition subsystem, telemetry preprocessors, and workstations are detailed. High speed telemetry processors make use of VAX 8600 coupled with Micro VAX II, while workstations use VAX 780, Micro VAX II, and techtonics displays. User software, data files, CRT displays, and intermaneuver mode are examined. L.K.S.

A91-19693*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REMOTE, PCM-CONTROLLED, MULTI-CHANNEL RADIO FREQUENCY FM TELEMETRY SYSTEM FOR CRYOGENIC WIND TUNNEL APPLICATION
JOHN K. DIAMOND (NASA, Langley Research Center, Hampton, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 619-632.

A telemetry system used in the NASA-Langley cryogenic transonic wind tunnel to obtain rotational strain and temperature data is described. The system consists of four FM transmitters allowing for a remotely controlled PCM combination. A rotating four-contact mercury slip-ring is used as an interface between the fixed and rotating mechnical structures. Over 60 channels of data on the main fan disk and blade structures have been obtained. These data are studied to verify computer predictions and mechanical life. A series of block diagrams are included. Y.P.Q.

N91-13461*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CALIBRATION OF THE 13- BY 13-INCH ADAPTIVE WALL TEST SECTION FOR THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
RAYMOND E. MINECK and ACQUILLA S. HILL Washington Dec. 1990 111 p
(NASA-TP-3049; L-16787; NAS 1.60:3049) Avail: NTIS HC/MF A06 CSCL 14/2

A 13 by 13 inch adaptive wall test section was installed in the 0.3 Meter Transonic Cryogenic Tunnel circuit. This new test section is configured for 2-D airfoil testing. It has four solid walls. The top and bottom walls are flexible and movable whereas the sidewalls are rigid and fixed. The wall adaptation strategy employed requires the test section wall shapes associated with uniform test section Mach number distributions. Calibration tests with the test section empty were conducted with the top and bottom walls linearly diverged to approach a uniform Mach number distribution. Pressure distributions were measured in the contraction cone, the test section, and the high speed diffuser at Mach numbers from 0.20 to 0.95 and Reynolds numbers from 10 to 100 x 10 (exp 6)/per foot. Author

N91-13462*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND-TUNNEL SURVEY OF AN OSCILLATING FLOW FIELD FOR APPLICATION TO MODEL HELICOPTER ROTOR TESTING
PAUL H. MIRICK, M-NABIL H. HAMOUDA, and WILLIAM T. YEAGER, JR. (Army Aerostructures Directorate, Hampton, VA.) Washington Dec. 1990 37 p
(Contract DA PROJ. 1L1-62211-A-47-AB)
(NASA-TM-4224; L-16757; NAS 1.15:4224;
AVSCOM-TR-90-B-007) Avail: NTIS HC/MF A03 CSCL 14/2

A survey was conducted of the flow field produced by the Airstream Oscillator System (AOS) in the Langley Transonic Dynamics Tunnel (TDT). The magnitude of a simulated gust field was measured at 15 locations in the plane of a typical model helicopter rotor when tested in the TDT using the Aeroelastic Rotor Experimental System (ARES) model. These measurements were made over a range of tunnel dynamic pressures typical of those used for an ARES test. The data indicate that the gust field produced by the AOS is non-uniform across the tunnel test section, but should be sufficient to excite a model rotor. Author

N91-13464# Army Engineer Waterways Experiment Station, Vicksburg, MS. Geotechnical Lab.
LITERATURE REVIEW ON GEOTEXTILES TO IMPROVE PAVEMENTS FOR GENERAL AVIATION AIRPORTS Final Report
DEWEY W. WHITE, JR. Oct. 1990 57 p Prepared in cooperation with Federal Aviation Administration, Washington, DC
(Contract DTFA01-89-Z-02029)
(DOT/FAA/RD-90/26) Avail: NTIS HC/MF A04

A literature search and review to obtain information on geotextile applications related to pavement construction are covered. This information was obtained for application to geotextiles in general aviation pavements. The study revealed that there are numerous design procedures available for using geotextiles in aggregate surface pavements and flexible pavement road construction. The state-of-the-art has not advanced to the point where design procedures for using geotextiles in paved airport construction are available. Construction/installation procedures are available for using geotextiles in aggregate surfaced pavements and flexible pavements for roads, and these may be used as an aid in recommending procedures for airport construction. Results of comprehensive tests by researchers indicate that geogrids have more potential than geotextiles for reinforcement of flexible pavements. Author

N91-13465# Federal Aviation Administration, Washington, DC.
LABORATORY INVESTIGATION OF THE USE OF GEOTEXTILES TO MITIGATE FROST HEAVE Final Report
KAREN S. HENRY (Army Cold Regions Research and Engineering Lab., Hanover, NH.) Aug. 1990 35 p
(DOT/FAA/RD-90/13; CRREL-90-6) Avail: NTIS HC/MF A03

Frost action beneath pavements can lead to several problems, including thaw weakening, which leads to cracking and subsequent pumping of fine soil particles onto the surface, as well as hazardous conditions caused by differential heaving. This study utilized data and frost-susceptible soil collected at Ravalli County Airport, Hamilton, Montant, to study the use of geotextiles to mitigate frost heave. The ability of geotectiles to reduce frost heave in subgrade material by creating a capillary break was assessed by inserting disks of fabric in soil samples and subjecting them to laboratory frost heave tests. Frost heave tests were also conducted to classify the frost-susceptibilities of soils at the airport. Soil moisture characteristics and unsaturated hydraulic conductivities were determined for soils tested as well as for one of the geotextiles used. Results of the laboratory investigation indicate that certain geotextiles show promise for use as capillary breaks. In laboratory tests, the presence of geotextiles led to the reduction of frost heave by amounts up to 60 percent. It is speculated that the capillary breaks action provided by the geotextile is attributable to the pore size and structure of the material and the surface properties of the fibers. Author

N91-13466*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TURBULENCE AND PRESSURE LOSS CHARACTERISTICS OF THE INLET VANES FOR THE 80- BY 120-FT WIND TUNNEL
MICHAEL R. DUDLEY Oct. 1990 23 p
(NASA-TM-102808; A-90123; NAS 1.15:102808) Avail: NTIS HC/MF A03 CSCL 14/2

A series of wind tunnel investigations were conducted to determine the flow characteristics downstream of a set of wind tunnel inlet flow conditioning vanes. The purpose was to develop an understanding of the flow mechanisms that contributed to the pressure loss and turbulence generated by the vane set. The near-field characteristics and flow field development were investigated with a 1/3 scale two dimensional model of the vane set at near full-scale Reynolds numbers. In a second series of tests, the global flow field characteristics were investigated by means of a 1/15 scale model of the full vane set and the 5:1 contraction leading to the model's test section. Scale effects due to Reynolds number mismatch were identified and their significance noted and accounted for when possible. Scaling parameters were adopted that allowed predictions to be made of the expected turbulence and pressure distributions in the full-scale wind tunnel test section, based on the small-scale test results. The predictions were found to be in good agreement with actual measurements made in the full-scale facility. Author

N91-13467*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATION OF PRESSURE AND TEMPERATURE RESPONSES FOR THE 20 INCH SUPERSONIC WIND TUNNEL
MARK A. MOTTER Dec. 1990 53 p
(NASA-TM-102647; NAS 1.15:102647) Avail: NTIS HC/MF A04 CSCL 14/2

A simulation of the pressure and temperature responses of the 20 inch Supersonic Wind Tunnel (SWT) is developed. The simulation models the tunnel system as a set of lumped parameter volumes connected by flow regulating elements such as valves and nozzles. Simulated transient responses of temperature and pressure for the five boundary points of the 20 inch SWT operating map are produced from their respective initial conditions, tunnel operating conditions, heater input power, and valve positions. Upon reaching steady state, a linearized model for each operating point is determined. Both simulated and actual tunnel responses are presented for comparison. Author

N91-13468 Institute for Perception RVO-TNO, Soesterberg (Netherlands).
SIMULATOR FLIGHT AS A SELECTION DEVICE: EFFECTS OF TEST ANXIETY ON SUBJECTIVE AND OBJECTIVE MEASURES OF PERFORMANCE Final Report
P. G. A. M. JORNA and R. T. B. VISSER 15 Mar. 1990 21 p (Contract A81/KM/126)
(IZF-1989-57; TD-89-4555; ETN-91-98306) Copyright Avail: Institute for Perception RVO-TNO, P.O. Box 23, 3769 ZG Soesterberg, Netherlands

The use of flight simulators as selection tools is discussed. Test procedures typically involve several flights in order to assess the trainability of an aspirant pilot. Performance is evaluated by an instructor and a positive grading is required to enter pilot training. The grading procedure as a selection tool, may confound situational stress responses with individual differences in information processing capacity. Situational or state-anxiety provoked by task demands and risk of failure could influence its validity by reducing the subjects' capacity for task-relevant information processing. The instances of anxiety are evaluated and their effects on flight performance studied by contrasting subjects with high and low levels of anxiety. Performance on these tests is evaluated by subjective instructor ratings and objective measures of flight control. ESA

N91-14354# Brookhaven National Lab., Upton, NY.
A CABLE VEHICLE BARRIER FOR ALERT AIRCRAFT PROTECTION
J. P. INDUSI, D. R. DOUGHERTY, and C. H. WAIDE 1990 11 p Presented at the Institute of Nuclear Materials Management Conference, Los Angeles, CA, 15-18 Jul. 1990
(Contract DE-AC02-76CH-00016)
(DE91-001723; BNL-44994; CONF-9007106-75) Avail: NTIS HC/MF A03

A cable vehicle barrier (CVB) for the protection of Strategic Air Command (SAC) alert aircraft parking areas was conceived, designed and tested under a program managed by the Weapons Laboratory of the U.S. Air Force. A barrier with proven capability against vehicles and readily removable in all situations was required to support the security police and, in time, reduce manpower requirements. The CVB spans a 300 ft gap across a taxiway used by alert tankers and bombers and must be capable of being lowered quickly to meet defense or emergency vehicle needs. The barrier consists of three impact cables linked together by nylon straps, supported by posts and pulleys, and held under tension using nylon rope shock absorbers. The barrier is raised and lowered using an electric winch; a manual winch provides for adjustment and emergency operation in the event of electric winch failure. The CVB was proven in vehicle impact tests at Kirtland AFB, NM, and the prototype unit has been tested operationally at Wurtsmith AFB, MI. DOE

N91-14356* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ELECTRO-OPTICAL SPIN MEASUREMENT SYSTEM Patent
ROBERT FODALE, inventor (to NASA) and HERBERT R. HAMPTON, inventor (to NASA) 12 Jun. 1990 7 p Filed 30 Sep. 1988
(NASA-CASE-LAR-13629-1; US-PATENT-4,932,777; US-PATENT-APPL-SN-251411; US-PATENT-CLASS-356-152; US-PATENT-CLASS-33-263; US-PATENT-CLASS-73-147; US-PATENT-CLASS-342-54; US-PATENT-CLASS-356-1; US-PATENT-CLASS-356-141; US-PATENT-CLASS-364-433)
Avail: US Patent and Trademark Office CSCL 14/2

An electro-optical spin measurement system for a spin model in a spin tunnel includes a radio controlled receiver/transmitter, targets located on the spin model, optical receivers mounted around the perimeter of the spin tunnel and the base of the spin tunnel for receiving data from the targets, and a control system for accumulating data from the radio controlled receiver and receivers. Six targets are employed. The spin model includes a fuselage, wings, nose, and tail. Two targets are located under the fuselage of the spin model at the nose tip and tail. Two targets are located on the side of the fuselage at the nose tip and tail, and a target is located under each wing tip. The targets under the fuselage at the nose tip and tail measure spin rate of the spin model, targets on the side of the fuselage at the nose tip and tail measure angle of attack of the spin model, and the targets under the wing tips measure roll angle of the spin model. Optical receivers are mounted at 90 degree increments around the periphery of the spin tunnel to determine angle of attack and roll angle measurements of the spin model. Optical receivers are also mounted at the base of the spin tunnel to define quadrant and position of the spin model and to determine the spin rate of the spin model.

Official Gazette of the U.S. Patent and Trademark Office

N91-14357* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WIND TUNNEL BALANCE Patent
WARREN L. HORNE, inventor (to NASA), NANS KUNZ, inventor (to NASA), PHILLIP M. LUNA, inventor (to NASA), ANDREW C. ROBERTS, inventor (to NASA), KENNETH M. SMITH, inventor (to NASA), and RONALD C. SMITH, inventor (to NASA) 11 Jul. 1989 10 p Filed 18 May 1988
(NASA-CASE-ARC-11877-1-SB; US-PATENT-4,845,993; US-PATENT-APPL-SN-195563; US-PATENT-CLASS-73-147; INT-PATENT-CLASS-G01M-9/00) Avail: US Patent and Trademark Office CSCL 14/2

A flow-through balance is provided which includes a non-metric portion and a metric portion which form a fluid-conducting passage in fluid communication with an internal bore in the sting. The non-metric and metric portions of the balance are integrally connected together by a plurality of flexure beams such that the non-metric portion, the metric portion and the flexure beams form a one-piece construction which eliminates mechanical hysteresis between the non-metric and the metric portion. The system includes structures for preventing the effects of temperature, pressure and pressurized fluid from producing asymmetric loads on the flexure beams. A temperature sensor and a pressure sensor are located within the fluid-conducting passage of the balance. The system includes a longitudinal bellows member connected at two ends to one of the non-metric portion and the metric portion and at an intermediate portion thereof to the other of (1) and (2). A plurality of strain gages are mounted on the flexure beams to measure strain forces on the flexure beams. The flexure beams are disposed so as to enable symmetric forces on the flexure beams to cancel out so that only asymmetric forces are measured as deviations by the strain gages.

Official Gazette of the U.S. Patent and Trademark Office

10

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A91-17009
PROGRAMMING THE MOTION OF FLIGHT VEHICLES IN AN ENCOUNTER PROCESS [PROGRAMMIROVANIE DVIZHENIIA LETATEL'NYKH APPARATOV V PROTSESSE VSTRECHI]
IU. Z. ALESHKOV IN: Dynamics of control systems. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, p. 141-147. In Russian. refs
Copyright

Ways to specify the three-dimensional motions of flight vehicles are described. Particular emphasis is placed on programming the motion of the vehicles in an encounter process by means of constraints on the parameters of their relative positions. Using

the proposed approach, an analysis is made of the motion of a flight vehicle in the vertical plane involving the targeting of a given point moving with a given velocity in a given direction. B.J.

A91-17088
DETERMINATION OF THE MOTION PARAMETERS OF A FLIGHT VEHICLE WITH A SIGNIFICANTLY VARYING SURFACE SHAPE [OPREDELENIE PARAMETROV DVIZHENIIA LETATEL'NOGO APPARATA S SUSHCHESTVENNO IZMENIAIUSHCHEISIA FORMOI POVERKHNOSTI]
IU. M. GOL'DSHTEIN and V. N. PENIA Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 4, 1989, p. 61-64. In Russian. refs
Copyright

A mathematical model has been developed which describes the motion of a bank-controlled aerodynamic descent module in the case of substantial nonsymmetric surface ablation. The incorporation of nonsymmetric base surface shapes makes it possible to extend methods originally developed for flight vehicles with a slightly changing surface shape to the case of bank-controlled aerodynamic descent vehicles. V.L.

A91-19244#
DYNAMIC RESPONSE OF AN AXISYMMETRIC THRUST VECTOR CONTROL NOZZLE
R. W. RYAN and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0344)

Dynamic response characteristics of an axisymmetric confined jet thrust vector control nozzle are described. Pressure fluctuations during axial and vectored flow conditions are determined from power spectral density content. Vectoring and unvectoring response times to secondary injection are studied. Side force response to a secondary injection pressure is analyzed. Effects of secondary injection geometry are considered. Author

A91-19270#
MHD ACCELERATOR FOR HYPERSONIC APPLICATIONS
J. T. LINEBERRY and J. N. CHAPMAN (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(AIAA PAPER 91-0384) Copyright

The potential use of MHD acceleration as a means to augment wind tunnel flows for simulation of hypersonic flight is discussed. A summary of hypersonic ground test needs to support the NASP program is given which identifies the hypervelocity flight regimes where the MHD accelerator can play a significant role in extending current ground test capabilities. This summary notes the capabilities of existing facilites and projects the extension of arc facilities with MHD augmentation. Past research directed at development of the MHD accelerator for ground testing is reviewed as is the physics of the accelerator processes. The results of recent studies on the potential application of the MHD accelerator to hypersonic environmental testing are presented. In addition to this, recent advances in all areas of MHD technology is cited to emphasis how the state-of-the-art in MHD has changed since the sixties accelerator research. These advances led to the conclusion that application of the MHD accelerator to hypersonic flight simulation is a technology that is at hand. And, MHD accelerator research needs to be initiated as a parallel effort to other ground test activities directed at extending the capacity of facilities to simulate hypervelocity flight. Author

A91-19654*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INSTRUMENTATION SYSTEMS FOR THE LANGLEY RESEARCH CENTER 8-FOOT HIGH TEMPERATURE TUNNEL
JAMES J. WALSH, JR. and LAURA A. O'CONNOR (NASA, Langley Research Center, Hampton, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 57-74.

A description is presented of the 8-foot high-temperature tunnel, a Mach 7 blowdown-type facility in which methane is burned in air under pressure, with the resulting combustion products utilized as the test medium. The instrumentation environment and requirements are identified, and instrumentation design, including wiring, sensors, and data acquisition system are described. The design and installation of a fast oxygen monitoring system to maintain the partial pressure of oxygen at 21 percent in the tunnel test section is included. Also, the new data acquisition system hardware details and data-reduction capabilities are defined. R.E.P.

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A91-17399
STRESS CONCENTRATION OF THE COMPOSITE MATERIAL USED BY THE X-29A FORWARD-SWEPT WING AIRCRAFT UNDER VARIOUS TEMPERATURE LEVELS
HSIEN-YANG YEH (California State University, Long Beach) and HSIEN-LIANG YEH (Texas, University, Arlington) IN: Composite structures 5; Proceedings of the Fifth International Conference, Paisley, Scotland, July 24-26, 1989. London, England and New York, Elsevier Applied Science, 1989, p. 535-545. refs
Copyright

The theory of anisotropic elasticity was used to evaluate the anisotropic stress concentration factors of a composite laminated plate containing a small circular hole. The results predicted by the constant strain approach matched the testing data very well at room temperature and were about 10-15 percent more conservative than the experimental data at elevated temperature (200 F). At low temperature (-60 F), the results predicted by the mixture rule approach provided good correlation with the experimental data. Furthermore, the experimental data showed the stress concentration decreased as the temperature increased. A simple random statistical study indicated that a fairly isotropic laminated plate is reached if the number of lamina with arbitrary orientation is greater than 40. Author

A91-17610
ADVANCED COMPOSITES
IVANA K. PARTRIDGE, ED. (Cranfield Institute of Technology, England) London, England and New York, Elsevier Applied Science, 1989, 445 p. For individual items see A91-17611 to A91-17622.
Copyright

Topics discussed in this book include high-temperature thermosetting matrix resins, continuous fiber-reinforced thermoplastic matrix composites, high-performance fibers, and approaches to toughness enhancement. Particular consideration is given to reinforced plastics in anticorrosion applications, inorganic matrix composites, advanced composite fabrication, and the design of bonded structures. Attention is also given to delamination, the fatigue of organic matrix composite materials, damage tolerance and damage assessment in advanced composites, and the certification of civil aircraft composite structures. I.S.

A91-18724
FLUORO-SILICONES AND FUEL CONTAINMENT
MYRON T. MAXSON (Dow Corning Corp., Midland, MI) Aerospace Engineering (ISSN 0736-2536), vol. 10, Dec. 1990, p. 15-18.
Copyright

Fluorosilicone, i.e., polytrifluoro-propylmethylsiloxane, sealants for fuel-sealing applications in high-performance aircraft are reviewed together with the existing noncuring/groove-injection

sealants, one-part fillet noncorrosive sealants, and two-part addition-curing sealants for deep-section or confined fay-surface application. Fluorosilicone-based sealants are developed for applications requiring noncuring sealants or sealants that use moisture-cure or confined-cure mechanisms. These sealants have excellent corrosion resistance to all grades of jet fuel and they are safe and easy to apply. They exhibit excellent primed adhesion and resistance to vibrations, moisture, and ozone, and have a wide service-temperature range of -57 to +260 C. A series of tables with properties and specifications is included. B.P.

A91-18918
MANUAL OF AVIATION FUEL QUALITY CONTROL PROCEDURES
RICK WAITE, ED. Philadelphia, PA, American Society for Testing and Materials, 1989, 89 p. No individual items are abstracted in this volume.
Copyright

Topics presented include the electrostatic hazards in mixing aviation fuels, the preservice cleanliness inspection of fueling equipment, a field test for the contamination of aviation gasoline with heavier fuels, and gravimetric membrane filtration test procedures. Also presented are a metrocator test for undissolved water, a filter element installation procedure, a Teflon coated screen separator, automatic water slug and dump systems, and a single element test for coalescers. R.E.P.

A91-19103#
3-D LDV MEASUREMENTS OF PARTICLE REBOUND CHARACTERISTICS
HASAN EROGLU (Carnegie-Mellon University, Pittsburgh, PA) and WIDEN TABAKOFF (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research sponsored by DOE. refs
(AIAA PAPER 91-0011) Copyright

This paper presents an experimental method to determine the three-dimensional particle rebound coefficients which can be used for particle trajectory calculations in turbomachinery, and in the semiempirical erosion correlations. Experiments were conducted using a three-component Laser Doppler Velocimeter system, and particle rebound characteristics were determined over flat target surfaces in a specially designed vertical wind tunnel. Particle materials is 15-micron mean diameter fly ash, and the target materials are INCO 718 and 2024 aluminum alloys. Author

A91-19126#
TURBULENT DIFFUSION FLAME PROPERTIES BEHIND A STEP
M. Z. WU, R. E. WALTERICK, W. A. DE GROOT, J. I. JAGODA, and W. C. STRAHLE (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract AF-AFOSR-88-0001)
(AIAA PAPER 91-0079) Copyright

Experiments and analysis are reported for a subsonic combustion windtunnel experiment, in which a turbulent diffusion flame is stabilized behind a backward facing step. A hydrogen and diluent fuel mixture is introduced through the porous floor behind the step. Velocity and temperature distributions were measured using laser Doppler velocimetry and Raman spectroscopy. The flow field was modeled analytically using a two equation turbulence model with Favre-averaged equations using the conserved scalar approach. Dominant features of the flow are a flame anchored primarily in the shear layer, a relatively cool recirculation zone and a long reattachment region compared with that for cold flow. The intensity of the Stokes line of nitrogen is shown to be an indication of the temperature of the flow. While the analysis correctly predicts the major features of the flow, it places the region of highest temperature closer to the floor than was observed experimentally. Author

A91-19312#
TWO-DIMENSIONAL IMAGING OF COMBUSTION PHENOMENA IN A SHOCK TUBE USING PLANAR LASER-INDUCED FLUORESCENCE
MICHAEL P. LEE, BRIAN K. MCMILLIN, JENNIFER L. PALMER, and RONALD K. HANSON (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by USAF. refs
(AIAA PAPER 91-0460) Copyright

Planar laser-induced fluorescence (PLIF) has been used to examine the mixing and combustion of a sonic jet of fuel injected transversely into a supersonic freestream of oxidizer flowing within a shock tube. Single-shot and frame-averaged PLIF images of NO and OH have been acquired for nonreacting and reacting flows in both side-view and end-view orientations. PLIF imaging of NO in the nonreacting flow allows examination of the penetration and structure of the jet independent of the effects of chemical reaction. PLIF imaging of OH in the reacting flow enables observation of regions where combustion occurs. The OH images indicate that combustion takes place primarily in the shear layer formed by the edge of the jet and the freestream and in the boundary layer adjacent to the wall. For both the nonreacting and reacting results, the single-shot images show the presence of structures not apparent in the frame-averaged images. Hence, these results demonstrate the need to examine the instantaneous mixing and combustion, since it is the instantaneous rather than time-averaged processes which govern the combustion. Author

A91-19365#
NUMERICAL STUDY ON MIXING AND COMBUSTION OF INJECTING HYDROGEN JET IN A SUPERSONIC AIR FLOW
A. KOICHI HAYASHI (Nagoya University, Japan) and MASAHIRO TAKAHASHI AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0574) Copyright

A two-dimensional sonic hydrogen jet transversely injected into a supersonic hot air flow is simulated numerically to understand the phenomena and mechanism of mixing and combustion processes. The flowfield is governed by the two-dimensional Reynolds averaged full Navier-Stokes equations with an algebraic eddy viscosity model developed by Baldwin and Lomax (1978). Chemical kinetics are described by 9 species (H2, O2, H2O, O, H, OH, HO2, H2O2 and N2) and 19 elementary reactions of the full hydrogen-oxygen system with the third body efficiencies assuming nitrogen is inert. The governing equations are solved full-implicitly using the implicit TVD scheme with the point-implicit treatments of chemical source terms. The numerical results are compared with a two-dimensional experiment to study validities of the turbulence model and chemical kinetics model. Author

A91-19718
AN APPRAISAL OF THE BALL-ON-CYLINDER TECHNIQUE FOR MEASURING AVIATION TURBINE FUEL LUBRICITY
J. W. HADLEY and P. BLACKHURST (Shell Research, Ltd., Thornton Research Centre, Chester, England) IN: STLE, Annual Meeting, 45th, Denver, CO, May 7-10, 1990, Preprints. Park Ridge, IL, Society of Tribologists and Lubrication Engineers, 1990, 8 p. refs
(STLE PREPRINT 90-AM-3C-1) Copyright

Mild wear measurements made in the Ball-on-Cylinder Lubricity Evaluator (BOCLE) are sometimes used to predict the scuffing limited performance of fuels in aircraft gear-type pumps. In this paper it is demonstrated that mild wear as measured in the BOCLE does not provide a unique description of scuffing tendencies: in fact, the relationship between mild wear and scuffing propensity is fuel dependent. A tribological study of the BOCLE shows that initial adhesion is rapidly followed by oxidative wear which subsequently dominates the test. Different boundary lubricating mechanisms are postulated in each wear regime and provide an explanation for the influence of fuel composition on scuffing and wear performance. Further studies show that the BOCLE can be operated in the scuffing mode, giving results which confirm the

above hypotheses and offer the possibility of using the BOCLE as a universal predictor of scuffing for aviation turbine fuels.
Author

A91-19915
EFFECT OF IONOL ON THE FORMATION OF DEPOSITS BY DIRECTLY DISTILLED JET FUELS [VLIIANIE IONOLA NA OBRAZOVANIE OTLOZHENII PRIAMOGONNYMI REAKTIVNYMI TOPLIVAMI]
E. P. SEREGIN, N. M. LIKHTEROVA, A. F. GORENKOV, V. G. GORODETSKII, I. A. LITVINOV et al. Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 11, 1990, p. 20-23. In Russian. refs
Copyright

Experimental results obtained for samples of TS-1, T-1, and T-2 jet fuels are presented to show that the thermal oxidation stability of directly distilled jet fuels can be increased through the modification of the disperse phase of colloidal solutions by ionol. By using this method, thermally stable aviation kerosenes can be produced at oil processing plants that lack hydrorefining facilities. It is noted that the effect of ionol on other fuel characteristics must be determined before final recommendations are given. In the absence of negative effects, the maximum amount of ionol that can be added to a fuel should not exceed 0.1 percent. V.L.

N91-13524# General Electric Co., Cincinnati, OH. Aircraft Engines Div.
RESEARCH AND DEVELOPMENT FOR IMPROVED TOUGHNESS ALUMINIDES Final Report, 1 Nov. 1985 - 31 Mar. 1989
B. J. MARQUARDT, G. K. SCARR, J. C. CHESNUTT, C. G. RHODES, and H. L. FRASER 11 Jun. 1990 179 p
(Contract F33615-85-C-5167; AF PROJ. 2420)
(AD-A226627; WRDC-TR-89-4133) Avail: NTIS HC/MF A09
CSCL 11/6

The basic mechanisms which can improve the toughness of alloys based on the intermetallic compound Ti3Al was identified and examined. The improved properties offered by these alloys will increase their potential for application in rotating components and critical static parts in advanced aircraft engines. The program was conducted in two separate phases which addressed iterative alloy/processing studies as well as alloy scale up concerns. In the first phase of the program, the effects of solid solution alloying, tough second phase, and dispersoid additions were evaluated in parallel tasks. Subsequently, alloys were designed to make use of additive and/or synergistic effects by combining the various alloying and processing concepts. In the second phase of the program, three of the more promising compositions were selected for scale up and further microstructural and property evaluations. GRA

N91-13530# Technical Research Centre of Finland, Espoo. Metals Lab.
MATERIAL DEGRADATION OF STEAM TURBINE ROTORS IN LONG TERM OPERATIONS
ULLA MCNIVEN, KLAUS RAHKA, RAUNO RINTAMAA, and PERTTI AUERKARI Jun. 1990 44 p In FINNISH; ENGLISH summary
(VTT-RR-692; ISBN-951-38-3714-9; ISSN-0358-5077; ETN-91-98275) Copyright Avail: NTIS HC/MF A03; Government Printing Centre, P.O. Box 516, SF-00101 Helsinki, Finland HC 40 Finnish marks

The material property degradation of steam turbine rotors was investigated. The main factors limiting the life of the HP rotor are thermal fatigue and possibly creep fatigue. The result can be a catastrophic fracture, if the growing defects are not detected in time. Fatigue and/or stress corrosion limit the life time of LP rotors. The final result is again a fast fracture and the rotor will be destroyed if growing defects are not detected early enough. The state of material properties can be determined by nondestructive testing, material testing, by analyzing the service history and the damages. ESA

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A91-17022
EXPERIMENTAL DETERMINATION OF THE HYDRODYNAMIC FORCE MOMENT DURING THE NONSYMMETRIC ENTRY OF A DISK INTO AN INCOMPRESSIBLE FLUID [EKSPERIMENTAL'NOE OPREDELENIE MOMENTA GIDRODINAMICHESKIKH SIL PRI NESIMMETRICHNOM PRONIKANII DISKA V SZHIMAEMUIU ZHIDKOST']
V. A. EROSHIN, G. A. KONSTANTINOV, N. I. ROMANENKOV, and IU. L. IAKIMOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1990, p. 88-94. In Russian. refs
Copyright

The nonsymmetric entry of a disk (circular cylinder) into an incompressible fluid is investigated experimentally using a fluid with a low sound velocity (a finely disperse medium with gas bubbles, whose dimensionless equation of state is the same as that for water). The experiments were conducted at entry angles of 54-88 deg, angles of attack between -15 and +15 deg, and Mach numbers of 0.002-0.2. Based on the experimental results, expressions are obtained for determining the hydrodynamic moment over a wide range of the above parameters. V.L.

A91-17214* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED ROTORCRAFT TRANSMISSION PROGRAM
ROBERT C. BILL (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 227-238. refs
Copyright

The U.S. Army/NASA Advanced Rotorcraft Transmission (ART) program is charged with developing and demonstrating a light, quiet, and durable drivetrain for next-generation rotorcraft in two classes: a 10,000-20,000 Future Attack Air Vehicle capable of both tactical ground support and air-to-air missions, and a 60,000-80,000 lb Advanced Cargo Aircraft, for heavy-lift field-support operations. Specific ART objectives encompass a 25-percent reduction in drivetrain weight, a 10-dB noise level reduction at the transmission source, and the achievement of a 5000-hr MTBF. Four candidate drivetrain systems have been carried to a conceptual design stage, together with projections of their mission performance and life-cycle costs. O.C.

A91-17215
DIAGNOSTIC SYSTEMS RESEARCH APPLICABLE TO HELICOPTER TRANSMISSIONS
H. JOHN ROSE (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 239-247. refs
Copyright

An evaluation is conducted of the prospective gains from several methods in helicopter transmission diagnostics recently studied by a major manufacturer. Attention is given to real-time vibration-signature analysis for the detection of incipient fatigue failures in transmission gears and shafts, which while potentially catastrophic are undetectable with current onboard diagnostic equipment. At the projected 65 percent twin-engine torque level time-scale, the time between microcrack initiation and failure may

be as short as 66 min after the triggering of the four most sensitive analysis techniques; this underscores the need for a real-time airborne warning system. O.C.

A91-17216
MODELING OF HELICOPTER TRANSMISSIONS FOR VIBRATION AND NOISE PREDICTION
M. MEYYAPPA, M. TOOSSI, and M. HASHEMI-KIA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 249-259. refs
Copyright

Finite element modeling of various transmission components is discussed. Emphasis is placed on developing a self-contained analytical model from data available during the design process. Only relevant details that are necessary to reproduce the overall dynamics of the components are retained in modeling so that the model does not become excessively large. The approach adopted is such that each component is modeled individually followed by the linking of the component models to obtain the overall transmission model. Procedures for assembling the component models are discussed. Application of the assembled model in gear-mesh excitation analysis is also discussed. Author

A91-17265
EVALUATION OF ADVANCED SANDWICH STRUCTURE DESIGNED FOR IMPROVED DURABILITY AND DAMAGE TOLERANCE
STEVEN LLORENTE, DOUGLAS WEEMS, and RUSSELL FAY (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 825-831.
Copyright

The application of advanced thin-gage sandwich panel structural components to helicopter airframes is discussed with a view to prospective improvements in the durability and damage-tolerance of such structures. An evaluation is conducted of the comparative structural performance of four sandwich panel types, respectively employing: (1) toughened thermoset resin face-sheets, (2) thermoplastic resin face-sheets, (3) interleaving, and (4) a denser core. Specimens using either a toughened thermoset reinforced by high strain-to-failure fibers or thermoplastic face-sheets exhibited substantly improved impact resistance over specimens fabricated on the basis of baseline face-sheets. O.C.

A91-17270
INTERACTIVE CURVE FOR FATIGUE LIFE PREDICTION OF A COMFLEX ROTOR FLEXURE
JOHN E. FALE, DUNCAN J. LAWRIE, and BHAGWATI P. GUPTA (Lord Corp., Erie, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 875-884.
Copyright

An interactive fatigue curve for a laminated Comflex beam (0 sub 8/+ or - 45 sub 2)s, based on static compressive strength under multiple loadings for a bearingless rotor flexure application, has been developed. This curve is used to predict the maximum combined loads for infinite life of the Comflex flexure. A three-dimensional finite element analysis, flexural static strength tests, and interlaminar shear strength tests of beams (0 sub 8/+ or - 45 sub 2)s, and flexural fatigue tests of uniaxial Comflex beams have been used to develop this curve. Author

A91-17301
COMPOSITE GROUP TECHNOLOGY DEVELOPMENT
KEVIN DEHOFF (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1269-1275.
Copyright

A comprehensive classification methodology for graphite composite assemblies was developed at Boeing Helicopters. This classification scheme was used to create a Group Technology (GT) database containing part features and attributes which capture both product and process definition. GT data is available to both Engineering and Operations personnel for retrieval and analysis. This paper will address the applications of group technology at Boeing Helicopters. In particular, the role of GT in Aircraft Design Build (concurrent engineering) processes will be highlighted. Examples of design standardization efforts for composite airframe structural parts will be discussed. In addition, the group technology foundation for cellular manufacturing and a methodology for planning future composite manufacturing facilities will be presented. Author

A91-17302
MAIN ROTORBLADE BONDING AUTOMATION
G. H. BURDORF, F. C. EDMAN, and R. W. GOBEIL (McDonnell Douglas Helicopter Co., Culver City, CA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1277-1281.
Copyright

All six types of MDHC's 300 and 500 Series Helicopter Main Rotor (M/R) blades have metal abrasion strips on their leading edges to provide additional wear protection. These abrasion strips are secondarily bonded to the M/R blade's leading edge, within strict bondline thickness tolerances. This operation must be done with a bonding tool that can provide proper heat transfer and pressure conditions that produce an excellent metal-to-metal bond between dissimilar metals. Furthermore, on some M/R blades, the tooling used to bond these abrasion strips cannot apply too much pressure aft of the leading edge spar due to the minimal structural support in this section of the M/R blade. Author

A91-17303
OPTIMIZING WIRE CRIMPS USING TAGUCHI DESIGNED EXPERIMENTS
TIMOTHY ZERBY, ANASTASIA DRAGUN, and LINDA GRAU (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1283-1292.
Copyright

In order to reduce the number of electrical connector problems on the Apache helicopter, Taguchi methods are used for identifying the factors that contribute to a good quality connection. Bad wire-to-pin crimps are identified as a major problem, a work group is formed with people from various disciplines that the problem affects, the problem is further defined by the group, and experimental control factors including crimp type and length, strip length, window centering, operators, and wire vendors are identified. Experimental procedures are laid out and conducted, and the experimental data is then analyzed. Crimp depth is identified as the major contributor to the strength of a crimped connection, while it is observed that undercrimping yields the highest pull-strength response and tolerance to different wire brands. V.T.

A91-17304
CASE STUDY OF CONTOURED TAPE LAYING FOR PRODUCTION
B. J. BENDA and J. P. FLEISCHMAN (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1293-1298.
Copyright

The constraints of a contour tape-laying machine (TLM) used for composite aircraft parts are identified, and the minimization of the effects of tool curvature and ply buildups throughout the part is considered. Overall part and tool-design constraints such as laps/gaps and ramp angles are discussed, as well as the role of the part-programming software, quality assurance considerations for inspection acceptance, the effect of caul plates, and bagging materials and procedures. The advantages of a TLM over hand layup, including reduced cost and better quality/repeatability are

described, and the importance of following design guidelines, establishing quality control features, and assuring material consistency are emphasized. V.T.

A91-17305
ROBOTIC WELDING OF SHEET METAL PARTS USING THE GTAW PROCESS
MIKE HARLOW, FRANK MARZANO (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ), and DALE PALMGREN (Arizona State University, Tempe) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1299-1306.

A successful robotic welding system using the gas tungsten arc welding process for welding of gas turbine engine, sheet metal components, has been implemented. Consideration to part configuration, definition of system requirements, development of the user interface, establishment of the justification philosophy, careful preparation of the bid specification, concluding with the system buyoff, ensured the successful implementation of the system. Author

A91-17377
FIBRE COMPOSITE REPAIRS TO DAMAGED STRUCTURAL COMPONENTS
R. JONES and J. PAUL (Defence Science and Technology Organization, Aeronautical Research Laboratories, Melbourne, Australia) IN: Composite structures 5; Proceedings of the Fifth International Conference, Paisley, Scotland, July 24-26, 1989. London, England and New York, Elsevier Applied Science, 1989, p. 1-37. refs

The design philosophy used to design repairs to thick sections is described, and the approach is illustrated by considering repairs to surface cracks, cracked bolt holes, and the recent reinforcement to the wing pivot fitting of an aircraft. The proposed repair consists of two discrete boron/epoxy doublers bonded to the upper surface of the aircraft over the stiffeners known to be subjected to high strains. Both unreinforced stiffener section and the reinforced section models are analyzed, and impact damage is assessed. A detailed three-dimensional finite-element analysis is undertaken in order to examine the mechanisms governing failure and residual strength. The possibility of using a temperature field for determining the stress distribution for composite repairs on operational aircraft is addressed. V.T.

A91-17870
DYNAMICAL BEHAVIOR OF AN ELASTIC ROTOR WITH SQUEEZE FILM DAMPER
O. BONNEAU, J. FRENE (Poitiers, Universite, France), A. KASSAI, and J. DER HAGOPIAN (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) IN: International Congress on Tribology, 5th, Espoo, Finland, June 12-15, 1989, Proceedings. Volume 4. Espoo, Finland, Finnish Society for Tribology, 1989, p. 145-150. refs

High speed rotors set a lot of stability problems especially when the speed of rotation is going through the first critical speed. The aim of this work is to model the behavior of a rotor considered like elastic with mass unbalance and mounted in a squeeze film damper. Two aspects are studied, the first is an investigation of different theoretical methods for calculation of a squeeze film damper, the second aspect is the modelization of the rotor, a pseudo modal method allows to reduce the size of the system. Effects of several parameters are presented, comparison between experimental and theoretical results have been done. Author

A91-18064
SYSTEM RELIABILITY OF A ROTATING SHAFT OF AN AIRCRAFT TAILPLANE
YUANSHENG FENG and KAN NI (Northwestern Polytechnical University, Xian, People's Republic of China) Computers and Structures (ISSN 0045-7949), vol. 37, no. 5, 1990, p. 833-836.

The rotating shaft of an aircraft tailplane can be considered as a structural system with several significant failure modes. Each significant failure mode is constituted by one critical cross-section of the shaft. The method of enumerating critical cross-sections is explained. All the significant failure modes are considered as series and correlative for computing the system reliability of the shaft. Author

A91-18079
AN INTRODUCTION TO THE THEORY OF FLUTTER [VVEDENIE V TEORIIU FLATTERA]
ROBERT E. LAMPER Moscow, Izdatel'stvo Mashinostroenie, 1990, 144 p. In Russian. refs

The problem of flight vehicle flutter and both theoretical and experimental solutions to this problem are examined. The principal hypotheses and assumptions, as well as the associated general properties of solutions to flutter problems are discussed. The discussion also covers similarity criteria, modeling of flutter in wind tunnels, and the main types of flutter and methods of their prevention. V.L.

A91-18345* Analatom, Inc., Sunnyvale, CA.
METHOD FOR MEASURING TEMPERATURES AND DENSITIES IN HYPERSONIC WIND TUNNEL AIR FLOWS USING LASER-INDUCED O2 FLUORESCENCE
GABRIEL LAUFER (Analatom, Inc., Sunnyvale, CA), ROBERT L. MCKENZIE, and DOUGLAS G. FLETCHER (NASA, Ames Research Center, Moffett Field, CA) Applied Optics (ISSN 0003-6935), vol. 29, Nov. 20, 1990, p. 4873-4883. refs

Laser-induced fluorescence in oxygen, in combination with Raman scattering, is shown to be an accurate means by which temperature, density, and their fluctuations owing to turbulence can be measured in air flows associated with high-speed wind tunnels. For temperatures above 60 K and densities above 0.01 amagat, the uncertainties in the temperature and density measurements can be less than 2 percent, if the signal uncertainties are dominated by photon statistical noise. The measurements are unaffected by collisional quenching and can be achieved with laser fluences for which nonlinear effects are insignificant. Temperature measurements using laser-induced fluorescence alone have been demonstrated at known densities in the range of low temperatures and densities which are expected in a hypersonic wind tunnel. Author

A91-18406
FINITE DIFFERENCE ANALYSIS OF INFINITE ARRAYS OF TWO-DIMENSIONAL MICROSTRIP STRUCTURES
J.-P. R. BAYARD (California State University, Sacramento) and D. H. SHAUBERT (Massachusetts, University, Amherst) IEE Proceedings, Part H - Microwaves, Antennas and Propagation (ISSN 0950-107X), vol. 137, pt. H, no. 6, Dec. 1990, p. 358-366. refs

Infinite arrays of two-dimensional printed elements are analyzed using the finite difference method. Grid models accounting for dielectric discontinuities and current continuity at rectangular junctions are developed. The procedure is used to study the behavior of three configurations of planar strips over dielectric substrates in an infinite array environment. These configurations include the 'dipole' element, the 'microstrip' element and the 'microstrip' element over an inhomogeneous substrate. For each configuration, calculated results are presented with special attention given to the correctness of antenna characteristics such as input impedance and scan performance. The results accurately predict antenna performance and comparison with published data confirms the method. Author

A91-18410
ELECTROMAGNETIC TRANSMISSION THROUGH A SMALL RADOME OF ARBITRARY SHAPE
E. ARVAS, A. RAHHALARABI, E. GUNDOGAN (Syracuse University, NY), and U. PEKEL (Ohio State University, Columbus) IEE Proceedings, Part H - Microwaves, Antennas and Propagation (ISSN 0950-107X), vol. 137, pt. H, no. 6, Dec. 1990, p. 401-405. refs
(Contract N00014-87-K-0366)

A simple moment solution is presented for the problem of electromagnetic transmission through small radomes of arbitrary shape. The equivalence principle is used to replace the radome by equivalent surface currents radiating into an unbounded medium. Boundary conditions on the tangential components of the magnetic and electric fields are used to obtain a set of coupled integral equations for the surface currents. The equations are solved using the method of moments, and the results are in very good agreement with available data. C.D.

A91-18427
SOME INFLUENCES OF PARTICLE SHAPE ON DRAG AND HEAT TRANSFER
H. A. DWYER (California, University, Davis) and D. S. DANDY (Sandia National Laboratories, Livermore, CA) Physics of Fluids A (ISSN 0899-8213), vol. 2, Dec. 1990, p. 2110-2118. Research supported by DOE and U.S. Army. refs

A comprehensive study of the three-dimensional flow of intermediate Re over an ellipsoid of revolution was carried out using a finite volume numerical method. Flowfields solutions show that the total skin friction drag and the total heat transfer correlate well with the particle surface area and are independent of particle orientation. For three-dimensional flows, the maximum in heat flux and total shear stress occurs at a different spatial location than the previous stagnation point in the flow. The maximum in the heat flux and the total shear stress usually occurs near the major axis of the body. The finite volume formulation of the transport equations appears to be a good framework for solving complex problems involving droplet mass transfer and deformation. C.D.

A91-18534
QUALIFICATION OF AN EDDY CURRENT AND A RADIOGRAPHIC CRACK INSPECTION FOR A MULTILAYER ALUMINIUM STRUCTURE
G. TOBER, T. MEIER, and C. STEINBERG (Messerschmitt-Boelkow-Blohm GmbH, Lemwerder, Federal Republic of Germany) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 1. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 321-329.

This report deals with an inspection method consisting of two nondestructive test procedures to detect fatigue cracks in a multilayer aluminum structure. The prepared eddy current/radiographic method is described. Information is given on the calibration, magnitudes and forms of indication as well as crack length determination; the influence of existing disturbance factors and the direction of incidence are discussed. In order to qualify both test methods, several original components were produced with fatigue cracks of different length. The crack lengths that can be found reliably as well as the influence of the direction of incidence on crack detection with the radiographic methods are stated. Author

A91-18536
MODERN ENGINEERING ACHIEVEMENTS IN THE FIELD OF AUTOMATIC FLUORESCENT PENETRANT INSPECTION PROCESS LINES
PIERRE CHEMIN (Ardrox, S.A., Paris, France) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 1. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 424-426.

Automatic fluorescent penetrant inspection process lines, until recently, were essentially designed for large production runs of components having a similar geometric configuration and relatively comparable surface roughness. Thus, once the operational parameters of the process line were established, they could not be readily or rapidly changed. A description is given of two process lines that are controlled by programmable automatic machines which can operate in the manual, automatic or semiautomatic mode. The manual or 'downgrade' mode is incorporated in order to enable processing to be performed in case of a malfunction in the transfer system. R.E.P.

A91-18542
INFLIGHT EARLY DETECTION OF CRACKS IN TURBINE AERO-ENGINE COMPRESSOR BLADES
R. KUDELSKI and R. SZCZEPANIK (Polish Society of Mechanical Engineering, Warsaw, Poland) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 1. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 616-622.

A phenomenon of the dynamic change of an aeroengine compressor blades' natural frequency in the course of fatigue crack propagation in their roots is described on the example of a Polish turbojet engine. On the ground of the this phenomenon, the main working principles of a device which measures vibrations of turbine-engine rotor blades, with application of the noninterferent discrete-phase method, used for early detection of first-stage compressor-blade cracks, are discussed. Author

A91-18545
ON-SITE VERIFICATION OF ALLOY MATERIALS WITH A NEW FIELD-PORTABLE XRF ANALYZER BASED ON A HIGH-RESOLUTION HGI2 SEMICONDUCTOR X-RAY DETECTOR
P. F. BERRY and G. R. VOOTS (Texas Nuclear, Austin) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 1. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 737-742. refs

A high-performance, field-portable, multielement XRF analyzer has been developed based on a new semiconductor X-ray detector of Mercuric Iodide. Its use for on-site verification of alloy materials is enhanced by a compact hand-held measurement probe design and ease of operation to simultaneously determine up to 21 elements with positive identification of 225-plus specified alloys. Materials of almost any shape or size can be analyzed and provisions are included for custom alloys and calibrations. Typical assay time is under 30s. Author

A91-18551
ACOUSTIC EMISSION - ITS INDUSTRIAL APPLICATIONS
R. PRASAD (National Institute of Foundry and Forge Technology, Ranchi, India) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 927-929. refs

Some basic properties and applications of continuously monitored, low-frequency acoustic emission (AE) signals are reviewed. It is pointed out that AE signals are able to detect and discriminate a required degradation mechanism in the presence of prevailing background noise and that the strength of AE signals depends on the type of material and deformation process. The applications feature monitoring of degradation processes such as fast phase transformation, stress corrosion, cracking of brittle surface coatings, leak detection, integrity of reactor pressure vessels, structural aircraft components during flight, slope stability, onset of rock-fall, and determination of fatigue life. B.P.

A91-18553
EDDY CURRENT TECHNIQUE FOR THE DETECTION AND SIZING OF FATIGUE CRACKS IN RIVET BORE HOLES ON AIRCRAFT
J. BERNARDI, C. GUERY (Dassaul Aviation, Saint-Cloud, France), F. HARDY, and R. SAMSON (TECRAD, Quebec, Canada) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1184-1189.
Copyright

A digital system for detection and sizing of axially oriented surface-fatigue cracks associated with aircraft rivet holes is presented. The system can locate cracks at the ends of rivet holes, minimizing the necessity of reboring and decreasing the inspection time. An eddy current (EC) profile can be obtained as the probe moves along the cracks in the axial direction. In order to apply the convolution principle, the impulse response of the probe has to be known. The equipment can perform a complete scanning of the rivet holes, detect possible fatigue cracks and monitor their gradual growth, characterize the cracks by adjusting and correcting the variations of the lift off and edge effects, and edit an inspection report. B.P.

A91-18554
AUTOMATED INSPECTION SYSTEMS FOR ULTRASONIC TESTING OF LARGE AIRCRAFT COMPONENTS
JOSEF FABIAN, ALBRECHT MAURER (NUKEM GmbH, Alzenau, Federal Republic of Germany), and PETER B. KRAUSE (Fraunhofer-Institut fuer Informations- und Datenverarbeitung, Karlsruhe, Federal Republic of Germany) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1190-1193.
Copyright

This paper discusses philosophies, special electronic equipment and advanced data acquisition systems used to perform ultrasonic inspection on special new aircraft components. Depending on the material under inspection, various techniques are used to detect amplitude and time of flight data for recognition of imperfections. The tight specifications for frequency- and dynamic range of inspection results require special instrumentation. The data acquisition system uses hardware graphic processing features to provide a flexible presentation of test results with respect to display size and scaling of acquired data. Furthermore, image analysis algorithms are used to automate evaluation and to reduce human error in the evaluation of inspection data. Author

A91-18555
ULTRASONIC SYSTEM FOR IN SERVICE NON DESTRUCTIVE INSPECTION OF COMPOSITE STRUCTURES
F. BOSCHETTI, F. CIPRI (Aeritalia S.p.A., Turin, Italy), and R. ROSSELLO (Airone, Turin, Italy) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1194-1200.
Copyright

In order to perform, directly on the airfield, the Non Destructive Inspection (NDI) of aerospace composite structures by means of equipments similar to those ones already utilized in the manufacturing workshops, a new ultrasonic system has been developed by Aeritalia and engineered by Airone Firm. The system includes an ultrasonic telemetry device for the geometrical location of the U.S. transducer position on the structure to be scanned and an instrumentation for the acquisition and processing of the ultrasonic data by C or B scan representation. The system operates in pulse echo mode and provides in real time a bidimensional representation of the intensity of the U.S. signals as well as the depth of the reflecting surface. Author

A91-18557
ULTRASONIC FIELD MODELLING FOR COMPLEX SHAPED AEROSPACE COMPONENTS
W. D. FEIST (MTU Motoren- und Turbinen-Union Muenchen, GmbH, Munich, Federal Republic of Germany) and W. MUELLER (Fraunhofer-Institut fuer zerstoerungsfreie Pruefverfahren, Saarbruecken, Federal Republic of Germany) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1206-1214.
Copyright

A computer program for ultrasonic testing of highly stressed jet-engine components such as turbine disks is presented. Since these components are increasingly made of powder-metallurgy nickel-based materials of very high homogeneity, they have to be inspected for inclusions at extremely high resolution. The inspection uses an immersion technique and high-resolution ultrasonic transducers adapted to the geometry of the components. The program uses FORTRAN and an HP-9020 computer with UNIX operating system for data input, calculation of sound fields, storage in data files, and sound-pressure representation of the sound fields. The sound distributions are stored and can be used for evaluation of ultrasonic data. B.P.

A91-18559
THE FOKKER BONDTESTER INSPECTION OF ARALL LAMINATES
J. L. SPEIJER (Fokker Aircraft, Schiphol, Netherlands) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1218-1222. refs
Copyright

The Fokker Bondtester has been employed to monitor delamination growth in several testpanels as part of a verification program on the structural performance of ARALL laminates. The Fokker Bondtester shows excellent performance in detecting delaminations and determining the depth of delaminated bondlines in ARALL structures. Results from a theoretical approach agree with the measurements. Author

A91-18562
NDT OF CARBON FIBRE COMPOSITE AIRCRAFT STRUCTURE IN THE RAF
J. H. ODELL (Central Servicing Development Establishment, Swanton Morley, England) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1229-1231.
Copyright

The RAF now faces the challenge of operating aircraft with major components of Carbon Fiber Composite (CFC) material. Likely forms of service damage have been identified, and impact damage trials have been carried out on a representative structure. Suitable methods of NDT have been identified, and have since been applied in the investigation of in-service damage. Author

A91-18569
US-INSPECTION OF CFRP-LAMINATES WITH HIGH RESOLUTION
W. HILLGER (DLR, Brunswick, Federal Republic of Germany) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1561-1566. refs
Copyright

US-testing, when used for the support of damage mechanics investigations on carbon-fiber reinforced plastics (CFRP), requires high resolution and high reproducibility. A high frequency equipment was developed in order to increase the axial and lateral resolution. A 50 MHz PVDF foil transducer detects 15 layer echoes in a defect-free laminate with a thickness of 2 mm. The S/N ratio of a 0.3 mm delamination echo amplitude is greater than 20 dB. The high resolution will be used for a B-scan system. Author

A91-18579
CHARACTERIZATION OF INSPECTION PERFORMANCE
J. H. HEIDA (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands) IN: Non-destructive testing; Proceedings of the Twelfth World Conference, Amsterdam, Netherlands, Apr. 23-28, 1989. Volume 2. Amsterdam, Netherlands and New York, Elsevier Science Publishers, 1989, p. 1711-1716. Previously announced in STAR as N90-26350.
Copyright

For a characterization of inspection performance it is necessary to consider both the Probability Of Detection (POD) of defects in flawed specimens and the Probability Of Recognition (POR) of unflawed specimens. Different aspects of this characterization are discussed. The magnetic inspection results of a test specimen population consisting of about 200 identical aircraft landing gear components are used. It is concluded that for a quantitative characterization of the inspection performance, minimum values for both the POD and POR must be established. A way to visualize the inspection performance is a diagram in which both POD and POR are presented. Author

A91-18597
NONDESTRUCTIVE INSPECTION OF JET ENGINE ASSEMBLIES AND COMPONENTS
RENEE S. DAVIS Materials Evaluation (ISSN 0025-5327), vol. 48, Dec. 1990, p. 1485, 1486-1490.
Copyright

The paper discusses basic NDT methods together with special NDT techniques (i.e., holography and computer tomography) as implemented in the production and in-field inspection procedures of jet engine components and assemblies. Companies which use holography to identify disbonds in parts made of composites and bonded fiberglass, computer tomography to make internal measurements on components that are inaccessible by other methods, and a microfocus X-ray technique to look for shrinkage and configuration defects are noted. B.P.

A91-18598
NONDESTRUCTIVE INSPECTION OF AGING AIRCRAFT STRUCTURE
DONALD J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 48, Dec. 1990, p. 1499, 1500, 1502-1504 (5 ff.). refs
Copyright

The paper presents an overview of NDI activities at Douglas Aircraft, conducted in order to ensure the continued airworthiness of the aircraft. An Aging Aircraft Nondestructive Working Group is established and its program contains three major initiatives including transfer of the best NDI technology to the persons responsible for inpsection, assessment of the current state of maintenance/repair, and new technologies. The main areas of concern are crack detection, corrosion detection, and lack of bond in lap joints. An electronic shearography technique which can detect and display a real-time video image of surface strain resulting from the presence of flaws when the part is stressed under a variety of loads and conditions is also presented. B.P.

A91-18777
CALCULATION OF BEAM-AIRFOIL INTEGRALS IN THE PROBLEM OF MOTION FOR A HIGH-LIFT WING WITH A FLEXIBLE AILERON [VYCHISLENIE BALOCHNO-PROFIL'NYKH INTEGRALOV V ZADACHE O DVIZHENII MEKHANIZIROVANNOGO KRYLA S GIBKIM ELERONOM]
IU. A. MOCHALOVA and E. V. POLIAKOVA Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), July 1990, p. 63-69. In Russian.
Copyright

A method is presented for calculating singular hydroelasticity integrals. The method is applied to the problem of motion of a thin high-lift wing with a flexible aileron in an incompressible subsonic stream. In the approach used here, an implementation of the Bubnov-Galerkin method leads to a system of integro-differential equations whose coefficients are dependent on the beam-airfoil integrals commonly encountered in hydroelasticity problems. V.L.

A91-18856
FLOW OF A PLANE SHOCK WAVE PAST A THERMAL ADJACENT TO A RIGID WALL [OB OBTEKANII TERMIKA, PRIMYKAIUSHCHEGO K ZHESTKOI STENKE, PLOSKOI UDARNOI VOLNOI]
B. I. ZASLAVSKII, S. IU. MOROZKIN, A. A. PROKOF'EV, and V. R. SHLEGEL' PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), May-June 1990, p. 15-23. In Russian. refs
Copyright

The interaction of a plane shock wave with a wall layer of a low-density gas (a wall thermal) was investigated experimentally over a wide range of the shock wave front incidence angles, wall layer densities, and shock wave intensities. Results of a theoretical analysis of the wave structure produced during such an interaction are also presented. Details of the experimental procedure and experimental equipment are described. V.L.

A91-19104*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EFFECTS OF YAW ON LOW ANGLE INJECTION INTO A SUPERSONIC FLOW
R. H. THOMAS, J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg), and E. J. FULLER AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Research supported by NASA. refs
(AIAA PAPER 91-0014) Copyright

This paper presents the results of a study of transverse gas injection into supersonic/hypersonic streams with low downstream transverse angles in addition to yaw angles varying from zero to approximately 30 deg. The primary data are concentration measurements, with nanoshadowgraphs and oil flow visualization pictures also included. Two sets of experiments were performed. The first set studied the effects of yaw angle, specifically beta = 15 and 28 deg, on a helium injector with a 30-deg transverse angle in a Mach 3 freestream. Axial measurement stations were x/d = 30, 50, and 100. It was found that, as beta was increased, the maximum concentration mixing rate did not vary, but the jet core penetration decreased more at beta = 15 deg than at beta = 28 deg. A shearing effect between the portion of the jet in the boundary layer and the portion in the freestream increased the area of a typical constant concentration contour. The second set of experiments, conducted at NASA Langley, studied the effect of yawed injection at a transverse angle of 15 deg in a Mach 6 flow. Axial stations of x/d = 20, 40, 60, and 80 were used. A yaw angle of beta = 15 deg was found to decrease both the jet core mixing rate and penetration. The primary benefit of yaw was to increase lateral spreading. For similar injection conditions, the results show less near-field mixing at Mach 6 than Mach 3, but a faster mixing rate in the far-field at Mach 6. Author

A91-19251#
FLOW-TAGGING VELOCIMETRY USING UV-PHOTODISSOCIATION OF WATER VAPOR
L. P. GOSS, T. H. CHEN, D. D. TRUMP, B. SARKA (Systems Research Laboratories, Inc., Dayton, OH), and A. S. NEJAD (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract F33615-88-C-2832)
(AIAA PAPER 91-0355)

The need to study high-speed flows for advanced propulsion systems has spurred the development of nonparticle laser-velocimetry techniques since techniques which rely upon seed particles, e.g., Laser Doppler Velocimetry, cannot be applied to this environment because of aerodynamic drag. OH-flow-tagging velocimetry is capable of velocity measurements in high- and low-speed flow systems. The technique involves photodissociation of the water molecule (a natural seed in most wind tunnels),

resulting in the formation of the OH photofragment which marks the flowfield. The displacement of the OH-photofragment is then measured as a function of time by laser-induced fluorescence. Because of the long chemical lifetime of the OH-photofragment (about 150 microsec, ambient), a wide range of velocity flowfields can be studied with the technique. Spectroscopic studies of water vapor and the OH-photofragment have been utilized to determine the optimum pump- and probe-laser wavelengths. Application of the technique to a high-speed underexpanded jet is demonstrated. Author

A91-19264#
INTERACTION BETWEEN CHEMICAL REACTION AND TURBULENCE IN SUPERSONIC NONPREMIXED H2-AIR COMBUSTION
R. VILLASENOR, R. W. PITZ (Vanderbilt University, Nashville, TN), and J.-Y. CHEN (Sandia National Laboratories, Livermore, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by Sandia National Laboratories and DOE. refs
(Contract NSF CBT-86-57131)
(AIAA PAPER 91-0375) Copyright

A numerical model for expanded supersonic turbulent jet flows with nonpremixed combustion of hydrogen and air is developed for exploring the potential interaction between chemical reaction and turbulence. The numerical code employs an implicit finite-volume, lower-upper successive overrelaxation scheme for solving the density-averaged Navier-Stokes equations and species transport equations for axisymmetric flows. Comparison of numerical results with and without the influence of turbulence on the chemical kinetics reveals that, even under the condition of weak turbulence, the effect of turbulence on chemistry can be significant. Author

A91-19275#
TURBULENCE TRANSITION CALCULATIONS USING FULL SECOND ORDER CLOSURE
LEONARD WALITT and MARTIN ROSENBLATT (California Research and Technology, Inc., Chatsworth) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0392) Copyright

A method has been developed to calculate transition to turbulence by solving the Reynolds-averaged Navier-Stokes equations, coupled with second order turbulence closure. Two transition mechanisms were considered; namely, aerodynamic noise and particulates in the environment. Models appropriate for inclusion of these transition mechanisms are presented. The method has been applied to three cases; namely, a cone-flare body in hypersonic flow, a sphere wake at reentry speed and a NASP vehicle in hypersonic flow. Computed results have been compared to corresponding experimental data for the three cases. On the balance agreement was good. Thus, second order closure is a viable means for computing transition on hypersonic vehicles. Author

A91-19283#
A SUMMARY OF EFFECTS OF HEAT TRANSFER ON AERODYNAMICS AND POSSIBLE IMPLICATIONS FOR WIND TUNNEL TESTS
D. G. MABEY (Royal Aerospace Establishment, Bedford, England) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0401) Copyright

This review summarizes the large effects of heat transfer on steady aerodynamics. Cooling the surface delays flow separation and thus is roughly equivalent to an increase in Reynolds number. Conversely heating promotes flow separation and is roughly equivalent to a decrease in Reynolds number. Cooling can also increase the extent of laminar boundary layers. These characteristics might be exploited to identify conditions for which large scale effects occur. The review has found no discussion of the effects of heat transfer on unsteady aerodynamics. From the steady effects some tentative suggestions are inferred about the probable influence of heat transfer on buffet excitation measurements in wind tunnels. Author

A91-19296#
MOVING WALL EFFECTS ON DYNAMIC STALL CAN BE LARGE - FACT OR FICTION?
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0430) Copyright

The answer to the stated question depends entirely on where the moving wall effects act. It will be shown that when they are concentrated to the birth place of the boundary layer, i.e., near the flow stagnation point, they are indeed large and completely dominate over the effects of accelerated flow and pressure gradient time history, whereas far downstream from flow stagnation the situation is reversed. Author

A91-19442*# Texas Univ., Austin.
EXPERIMENTS CONCERNING THE THEORIES OF VORTEX BREAKDOWN
RONALD L. PANTON (Texas, University, Austin) and KIRK E. STIFLE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 22 p. refs
(Contract NAG2-398)
(AIAA PAPER 91-0736)

An experimental project was undertaken to investigate the character of vortex breakdown with particular regard to the stagnation and wave guide theories of vortex breakdown. Three different wings were used to produce a trailing vortex which convected downstream without undergoing breakdown. Disturbances were then introduced onto the vortex using a moving wire to 'cut' the vortex. The development of upstream and downstream propagating disturbance waves was observed and the propagation velocities measured. A downstream traveling wave was observed to produce a structure similar in appearance to a vortex breakdown. An upstream traveling wave produced a moving turbulent region. The upstream disturbance moved into an axial velocity profile that had a wake-like defect while the downstream moving vortex breakdown moved against a jet-like overshoot. The longitudinal and swirl velocity profiles were documented by LDV measurement. Wave velocities, swirl angles, and swirl parameters are reported. Author

A91-19446#
FLOW INDUCED VIBRATIONS OF THIN LEADING EDGES
R. A. GRANGER (U.S. Naval Academy, Annapolis, MD) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract F49620-88-C-0053)
(AIAA PAPER 91-0745)

Leading edge vibrations occur in a wide variety of applications, e.g., rotary dynamics, turbomachinery and unsteady aeroelasticity. The physics of leading edge vibrations is not precisely known, so four separate theoretical investigations were made, each investigation based on a different physical model which in turn is governed by distinct phenomenon. Only one mathematical model is presented herein. It is based on Lamb's formulation that the phenomenon is a highly nonlinear response. The nonlinear differential equation was solved in closed analytical form using Poincare's method of expanding solutions. The theoretical results for the case of negligible structural damping compared favorably with preliminary experimental measurements. Author

A91-19447*#
PANEL FLUTTER IN A LOW-DENSITY ATMOSPHERE
HUGO B. RESENDE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NGL-05-020-243)
(AIAA PAPER 91-0746) Copyright

The problem of panel flutter is considered in the case of a free-molecule flow, the effect of the aerodynamic shear stress

being incorporated into the structural model through distributed longitudinal and bending moment loads. This kind of analysis is relevant in the case of hypersonic flight vehicles, like the NASP, especially because in these conditions the shear stress can be expected to be considerably larger that the pressure at a given point. The aerodynamic loading is derived assuming a quasi-steady approximation. Two important parameters are given by alpha-m, the 'momentum accommodation coefficient', and Theta, the temperature ratio between the panel temperature and the temperature of the undisturbed flow. For high enough values of Theta the variation of the linear flutter parameter with alpha-m is close to linear. Comparison with continuum theory, given by linear piston theory, depends on the values of Theta and alpha-m considered. Finally, it is shown that buckling with respect to a uniform distributed longitudinal load is stabilizing. Author

A91-19589
FLOW VISUALIZATION AND SIMULATION [VISUALISATION ET SIMULATION D'ECOULEMENTS]
A. NAIM, T. PRE, and T. CHEVALIER (Dassault Aviation, Departement des Etudes Theoriques Aerodynamiques, Saint-Cloud, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 23 p. In French.
(AAAF PAPER NT 89-18) Copyright

The development of interactive visualization tools for the study of aircraft models is examined. The philosophy underlying the development of interactive software is elaborated, and attention is given to types of available visualizations and visualization limits. Features of image analysis and animation techniques in this domain are then discussed. B.J.

A91-19594
MEASUREMENT OF THE AVERAGE LOCAL DENSITY AROUND A MODEL FROM WHICH A LATERAL JET ISSUES INTO SUPERSONIC FLOW [MESURE DE LA MASSE VOLUMIQUE MOYENNE LOCALE, AUTOUR D'UNE MAQUETTE MUNIE D'UN JET LATERAL, EN ECOULEMENT SUPERSONIQUE]
L. BOBIN (Saint-Lois, Institut Franco-Allemand de Recherches, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 13 p. In French. refs
(AAAF PAPER NT 89-08) Copyright

Experimental results are presented on a cylindrical-conical body of revolution, the cylindrical part of which is equipped with a contoured nozzle ejecting a cold jet of methane normal to the wind-tunnel flow (M = 2). The confluence was investigated by using stimulated Raman scattering (SRS) to measure the average local density of the air and of the ejected methane. The results obtained are confirmed by predictions made for a flow in the absence of a jet. The experimental results confirm the effectiveness of SRS as a 'nonintrusive' measurement technique in aerodynamics. B.J.

A91-19595
THE RADAC SYSTEM FOR MEASURING MODEL DEFORMATIONS - FIRST EXPERIMENTAL RESULTS OBTAINED IN THE F1 WIND TUNNEL [DISPOSITIF RADAC DE MESURE DES DEFORMATIONS DE MAQUETTE - PREMIERS RESULTATS EXPERIMENTAUX DANS LA SOUFFLERIE F1]
B. LAMISCARRE, B. SIDORUK (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), E. CASTAN, and M. BAZIN (ONERA, Chatillon, France) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 21 p. In French. refs
(AAAF PAPER NT 89-03) Copyright

The RADAC measuring system developed for the ONERA large wind tunnels is designed to study the deformations of models under the effects of aerodynamic forces. The basics of this three-dimensional stereo readout system are described. The system consists of two cameras and acquisition and data processing instruments. The first deformation measurements obtained from a 1/2 scale model at the wind tunnel wall appear to be consistent and the accuracy is close to the specifications. R.E.P.

A91-19652#
SURVEY OF TURBINE ENGINE FUEL FLOW MEASUREMENT PRACTICES IN NATO TEST FACILITIES
J. W. THOMPSON, JR. and W. O. BOALS, JR. (Sverdrup Technology, Inc., Arnold AFB, TN) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 17-25. refs

Due to the critical nature of turbine engine test measurements and their influence on aircraft performance predictions, as well as the need for a sound knowledge of test-related factors which may influence such measurements, NATO countries have supported an interfacility Uniform Engine Test Program (UETP) in order to compare critical measurements. A comparison is made of calibration approaches and practices, data reduction methods, instrumentation techniques, and measurement uncertainty assessments. Then an ideal steady-state fuel flow measurement system is described based on a selection of the best approaches from the five countries involved. The UETP utilization of a single measurement uncertainty technique proved to be absolutely necessary to improve understanding and comparisons between facilities of measurement systems and test performance results. R.E.P.

A91-19671*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AUTOMATED THERMAL MAPPING TECHNIQUES USING CHROMATIC IMAGE ANALYSIS
GREGORY M. BUCK (NASA, Langley Research Center, Hampton, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 275-283. Previously announced in STAR as N89-25443. refs

Thermal imaging techniques are introduced using a chromatic image analysis system and temperature sensitive coatings. These techniques are used for thermal mapping and surface heat transfer measurements on aerothermodynamic test models in hypersonic wind tunnels. Measurements are made on complex vehicle configurations in a timely manner and at minimal expense. The image analysis system uses separate wavelength filtered images to analyze surface spectral intensity data. The system was initially developed for quantitative surface temperature mapping using two-color thermographic phosphors but was found useful in interpreting phase change paint and liquid crystal data as well. Author

A91-19682#
NONCONTACT BLADE DEFLECTION MEASUREMENT SYSTEMS FOR ROTATING BLADED DISKS
SWAMINADHAM MIDTURI, ROBERT J. DOMINIC (Dayton, University, OH), JOHN D. REED, and WILLIAM A. STANGE (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 455-468. refs

This paper describes two noncontacting instrumentation systems that have been used to measure the vibratory motion of rotating bladed disks. The first system deals with the measurement of the time-of-arrival of blade tips by fiber optic probes. Concept and design of a four-channel plane of light optical sensor system and its adaptation to measuring the non-integral and integral order vibrations of a simple rotating bladed disk are described. Data acquisition, analysis, and display features of this system are also presented. The second measurement system, based on case-mounted grids, is used to measure the axial and tangential components of vibratory motion of a single blade of a rotating bladed disk. Its applicability to describing the modal deformation of the test disk is explained. The relative merits of these two measurement systems are described in terms of their data acquisition and analysis capabilities. Author

A91-19695#
EXTERNAL PRESSURE MEASUREMENT SYSTEM

JON K. CHANDLER (U.S. Navy, Puget Sound Naval Shipyard, Bremerton, WA) and DON P. FOWLER (Boeing Commercial Airplanes, Renton, WA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 653-661.

Hydraulic systems comprise an important part of jet aircraft and their pressure needs must be checked constantly. Tests of the prototype external pressure measurement system show that it is possible to accurately convert the small expansion of tubing with pressure into a direct pressure reading without inserting a pressure gage into the piping system. The tool described in the paper is a clamp-on displacement transducer that can read pressure directly in PSI from 0 to 5000. Some limitations concerning temperature and accuracy should be remedied by additional design work. The system promises to streamline troubleshooting of all types of piping systems. Y.P.Q.

A91-19712* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD FOR MONITORING NUCLEAR ABSORPTION COEFFICIENTS OF AVIATION FUELS
DANNY R. SPRINKLE (NASA, Langley Research Center, Hampton, VA) and CHIH-PING SHEN (Old Dominion University, Norfolk, VA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 853-858. Previously announced in STAR as N89-12234. refs
Copyright

A technique for monitoring variability in the nuclear absorption characteristics of aviation fuels has been developed. It is based on a highly collimated low energy gamma radiation source and a sodium iodide counter. The source and the counter assembly are separated by a geometrically well-defined test fuel cell. A computer program for determining the mass attenuation coefficient of the test fuel sample, based on the data acquired for a preset counting period, has been developed and tested on several types of aviation fuel. Author

A91-19816* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON THE REVERSE FLOW CEILING JET IN POOL FIRE-VENTILATION CROSSFLOW INTERACTIONS IN A SIMULATED AIRCRAFT CABIN INTERIOR
E. Y. KWACK, C. P. BANKSTON, P. SHAKKOTTAI, and L. H. BACK (JPL, Pasadena, CA) IN: Current topics in structural mechanics. New York, American Society of Mechanical Engineers, 1989, p. 101-108. refs
Copyright

The behavior of the reverse flow ceiling jet against the ventilation flow from 0.58 to 0.87 m/s was investigated in a 1/3 scale model of a wide body aircraft interior. For all tests, strong reverse-flow ceiling jets of hot gases were detected well upstream of the fire. Both thicknesses of the reverse-flow ceiling jet and the smoke layer increased with the fire-crossflow parameter. The thickness of the smoke layer where the smoke flows along the main flow below the reverse-flow ceiling jet was almost twice that of the reverse-flow ceiling jet. Detailed spatial and time-varying temperatures of the gas in the test section were measured, and velocity profiles were also measured using a temperature compensated hot film. Author

A91-20335
VIBRATION ANALYSIS OF COMPOSITE PLATE WING
I. LEE and J. J. LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) Computers and Structures (ISSN 0045-7949), vol. 37, no. 6, 1990, p. 1077-1085. refs
Copyright

The effects of fiber orientation and aspect ratio on the natural frequencies and mode shapes of a laminate composite wing are investigated by means of FEM computations. The 8-node quadrilateral element employed is formulated on the basis of the shear-deformable plate theory of Yang et al. (1966). The results are presented in extensive graphs and diagrams and discussed in detail, with a focus on the appearance of frequency-closeness phenomena with negative fiber angles. In a 0(2)+/-30 unswept rectangular panel, for example, the third, fourth, and fifth frequencies become close near an aspect ratio of 1.7. T.K.

A91-20396#
ANALYSIS FOR TYPICAL STATOR BLADE STRUCTURE AND ITS IMPLEMENTATION
CHUNHANG QIU, DOUKUI YU, JIXIN LIANG, and DONG LI (Dalian University, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, Oct. 1990, p. 367, 368. In Chinese, with abstract in English.

A program named STAP for the stator blade analysis with preprocessor and postprocessor is briefly introduced. Using the mesh generation and substructure assemblage functions of STAP, it is possible to accomplish conveniently stress and vibration analyses of the stator blade if only the coordinates of points on the contour of a blade and a few of the mechanical properties of materials are known. Since mechanical properties, particularly Young's modulus and coefficient of thermal expansion, are temperature-dependent, it is very important to take this fact into account for calculating the stress of a cooled gas turbine blade. To this end, STAP provides the user with a finite element method with a temperature dependence on the properties. In structure modeling, in order to reduce the number of unknown variables and to describe the complex boundary conditions, STAP is possessed of the function of Master-Slave relations between the nodal displacements. Author

N91-13649*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
FLOW ESTABLISHMENT IN A GENERIC SCRAMJET COMBUSTOR Final Report
P. A. JACOBS, R. C. ROGERS, E. H. WEIDNER, and R. D. BITTNER (Analytical Services and Materials, Inc., Hampton, VA.) Oct. 1990 41 p Submitted for publication
(Contract NAS1-18605)
(NASA-CR-187467; ICASE-90-77; NAS 1.26:187467) Avail: NTIS HC/MF A03 CSCL 20/4

The establishment of a quasi-steady flow in a generic scramjet combustor was studied for the case of a time varying inflow to the combustor. Such transient flow is characteristic of the reflected shock tunnel and expansion tube test facilities. Several numerical simulations of hypervelocity flow through a straight duct combustor with either a side wall step fuel injector or a centrally located strut injector are presented. Comparisons were made between impulsively started but otherwise constant flow conditions (typical of the expansion tube or tailored operations of the reflected shock tunnel) and the relaxing flow produced by the 'undertailored' operations of the reflected shock tunnel. Generally the inviscid flow features, such as the shock pattern and pressure distribution, were unaffected by the time varying inlet conditions and approached steady state in approx. the times indicated by experimental correlations. However, viscous features, such as heat transfer and skin friction, were altered by the relaxing inlet flow conditions. Author

N91-13651*# Queensland Univ., Saint Lucia (Australia). Dept. of Mechanical Engineering
SHOCK TUNNEL STUDIES OF SCRAMJET PHENOMENA, SUPPLEMENT 5 Interim Report
R. CASEY, R. J. STALKER, C. P. BRESCIANINI, R. G. MORGAN, P. A. JACOBS, M. WENDT, N. R. WARD, N. AKMAN, G. A. ALLEN, and K. SKINNER Oct. 1990 200 p
(Contract NAGW-674)
(NASA-CR-182096-SUPPL-5; NAS 1.26:182096-SUPPL-5) Avail: NTIS HC/MF A09 CSCL 20/4

A series of reports are presented on SCRAMjet studies, shock tunnel studies, and expansion tube studies. The SCRAMjet studies include: (1) Investigation of a Supersonic Combustion Layer; (2) Wall Injected SCRAMjet Experiments; (3) Supersonic Combustion with Transvers, Circular, Wall Jets; (4) Dissociated Test Gas Effects

on SCRAMjet Combustors; (5) Use of Silane as a Fuel Additive for Hypersonic Thrust Production, (6) Pressure-length Correlations in Supersonic Combustion; (7) Hot Hydrogen Injection Technique for Shock Tunnels; (8) Heat Release - Wave Interaction Phenomena in Hypersonic Flows; (9) A Study of the Wave Drag in Hypersonic SCRAMjets; (10) Parametric Study of Thrust Production in the Two Dimensional SCRAMjet; (11) The Design of a Mass Spectrometer for use in Hypersonic Impulse Facilities; and (12) Development of a Skin Friction Gauge for use in an Impulse Facility. The shock tunnel studies include: (1) Hypervelocity flow in Axisymmetric Nozzles; (2) Shock Tunnel Development; and (3) Real Gas Efects in Hypervelocity Flows over an Inclined Cone. The expansion tube studies include: (1) Investigation of Flow Characteristics in TQ Expansion Tube; and (2) Disturbances in the Driver Gas of a Shock Tube. K.S.

N91-13676*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.

A QUIET FLOW LUDWIEG TUBE FOR STUDY OF TRANSITION IN COMPRESSIBLE BOUNDARY LAYERS: DESIGN AND FEASIBILITY Semiannual Status Report, 1 May - 1 Nov. 1990

STEVEN P. SCHNEIDER Nov. 1990 24 p

(Contract NAG1-1133)

(NASA-CR-187374; NAS 1.26:187374) Avail: NTIS HC/MF A03 CSCL 14/2

Since Ludwieg tubes have been around for many years, and NASA has already established the feasibility of creating quiet-flow wind tunnels, the major question addressed was the cost of the proposed facility. Cost estimates were obtained for major system components, and new designs which allowed fabrication at lower cost were developed. A large fraction of the facility cost comes from the fabrication of the highly polished quiet-flow supersonic nozzle. Methods for the design of this nozzle were studied at length in an attempt to find an effective but less expensive design. Progress was sufficient to show that a quality facility can be fabricated at a reasonable cost. Author

N91-13687*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DUAL STRAIN GAGE BALANCE SYSTEM FOR MEASURING LIGHT LOADS Patent Application

PAUL W. ROBERTS, inventor (to NASA) 18 Sep. 1990 20 p

(NASA-CASE-LAR-14419-1; NAS 1.71:LAR-14419-1; US-PATENT-APPL-SN-584018) Avail: NTIS HC/MF A03 CSCL 14/2

A dual strain gage balance system for measuring normal and axial forces and pitching moment of a metric airfoil model imparted by aerodynamic loads applied to the airfoil model during wind tunnel testing includes a pair of non-metric panels being rigidly connected to and extending towards each other from opposite sides of the wind tunnel, and a pair of strain gage balances, each connected to one of the non-metric panels and to one of the opposite ends of the metric airfoil model for mounting the metric airfoil model between the pair of non-metric panels. Each strain gage balance has a first measuring section for mounting a first strain gage bridge for measuring normal force and pitching moment and a second measuring section for mounting a second strain gage bridge for measuring axial force. NASA

N91-13751*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FAILURE BEHAVIOR OF GENERIC METALLIC AND COMPOSITE AIRCRAFT STRUCTURAL COMPONENTS UNDER CRASH LOADS

HUEY D. CARDEN and MARTHA P. ROBINSON Washington Nov. 1990 48 p

(NASA-RP-1239; L-16744; NAS 1.61:1239) Avail: NTIS HC/MF A03 CSCL 20/11

Failure behavior results are presented from crash dynamics research using concepts of aircraft elements and substructure not necessarily designed or optimized for energy absorption or crash loading considerations. To achieve desired new designs incorporating improved energy absorption capabilities often requires an understanding of how more conventional designs behave under crash loadings. Experimental and analytical data are presented which indicate some general trends in the failure behavior of a class of composite structures including individual fuselage frames, skeleton subfloors with stringers and floor beams without skin covering, and subfloors with skin added to the frame-stringer arrangement. Although the behavior is complex, a strong similarity in the static/dynamic failure behavior among these structures is illustrated through photographs of the experimental results and through analytical data of generic composite structural models. Author

N91-13762*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

GENERAL ROTORCRAFT AEROMECHANICAL STABILITY PROGRAM (GRASP): THEORY MANUAL

DEWEY H. HODGES, A. STEWART HOPKINS, DONALD L. KUNZ, and HOWARD E. HINNANT Oct. 1990 150 p Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA

(NASA-TM-102255; A-90014; NAS 1.15:102255; USAAVSCOM-TM-89-A-003) Avail: NTIS HC/MF A07 CSCL 20/11

The general rotorcraft aeromechanical stability program (GRASP) was developed to calculate aeroelastic stability for rotorcraft in hovering flight, vertical flight, and ground contact conditions. GRASP is described in terms of its capabilities and its philosophy of modeling. The equations of motion that govern the physical system are described, as well as the analytical approximations used to derive them. The equations include the kinematical equation, the element equations, and the constraint equations. In addition, the solution procedures used by GRASP are described. GRASP is capable of treating the nonlinear static and linearized dynamic behavior of structures represented by arbitrary collections of rigid-body and beam elements. These elements may be connected in an arbitrary fashion, and are permitted to have large relative motions. The main limitation of this analysis is that periodic coefficient effects are not treated, restricting rotorcraft flight conditions to hover, axial flight, and ground contact. Instead of following the methods employed in other rotorcraft programs. GRASP is designed to be a hybrid of the finite-element method and the multibody methods used in spacecraft analysis. GRASP differs from traditional finite-element programs by allowing multiple levels of substructure in which the substructures can move and/or rotate relative to others with no small-angle approximations. This capability facilitates the modeling of rotorcraft structures, including the rotating/nonrotating interface and the details of the blade/root kinematics for various types. GRASP differs from traditional multibody programs by considering aeroelastic effects, including inflow dynamics (simple unsteady aerodynamics) and nonlinear aerodynamic coefficients. Author

N91-14040# TRW, Inc., Redondo Beach, CA. Space and Technology Group.

ANALOG SUPERCONDUCTIVE ELECTRONICS FOR AVIONICS

A. H. SILVER and A. D. SMITH *In* AGARD, Applications of Superconductivity to Avionics 5 p Oct. 1990

Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Superconductive electronics may solve critical problems in avionic sensors and signal processing. This results from both fundamental considerations such as low RF loss and power dissipation, flux quantization, and the Josephson effect. Because new physical mechanisms can be applied, new device configurations can be employed. This presentation describes the state-of-the-art and project near-term applications. Examples of high leverage superconductive technology in analog signal processing, analog-to-digital converters, low noise receivers, and phased array components are presented. Both high temperature copper-oxides and low temperature metallic superconductors are discussed. Author

N91-14508* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ELECTROSTATICALLY SUSPENDED ROTOR FOR ANGULAR ENCODER Patent
WALTER POLSTORFF, inventor (to NASA) 23 Oct. 1990 13 p Filed 21 Aug. 1989
(NASA-CASE-MFS-28294-1; US-PATENT-4,965,429; US-PATENT-APPL-SN-396262; US-PATENT-CLASS-219-121.68; INT-PATENT-CLASS-B23K-26/00) Avail: US Patent and Application Office CSCL 13/2

An apparatus for engraving a code strip with coded markings is disclosed. The code strip is attached for rotation to a cylindrical rotor which is mounted within the cavity of a stator. The stator carries electrodes on its top and side walls to which high potentials are applied to electrostatically suspend the rotor. Circuit means sense the position of the rotor with respect to the stator electrodes and adjust the potential to maintain the rotor at its desired location. A drive motor is connected to the rotor through a drive shaft to initially lift the rotor into the desired location within the stator and to rotate it at the desired speed. Thereafter, the drive shaft is disconnected from the rotor, and the rotor continues to spin at a highly stable angular velocity, supported only by the electrostatic fields. Official Gazette of the U.S. Patent and Trademark Office

N91-14540*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODELING AND CONTROL DESIGN OF A WIND TUNNEL MODEL SUPPORT
DAVID A. HOWE Nov. 1990 11 p Prepared for presentation at the 9th International Model Analysis Conference, Florence, Italy, 15-16 Apr. 1991
(NASA-TM-103829; A-91008; NAS 1.15:103829) Avail: NTIS HC/MF A03 CSCL 09/3

The 12-Foot Pressure Wind Tunnel at Ames Research Center is being restored. A major part of the restoration is the complete redesign of the aircraft model supports and their associated control systems. An accurate trajectory control servo system capable of positioning a model (with no measurable overshoot) is needed. Extremely small errors in scaled-model pitch angle can increase airline fuel costs for the final aircraft configuration by millions of dollars. In order to make a mechanism sufficiently accurate in pitch, a detailed structural and control-system model must be created and then simulated on a digital computer. The model must contain linear representations of the mechanical system, including masses, springs, and damping in order to determine system modes. Electrical components, both analog and digital, linear and nonlinear must also be simulated. The model of the entire closed-loop system must then be tuned to control the modes of the flexible model-support structure. The development of a system model, the control modal analysis, and the control-system design are discussed. Author

N91-14589# Mechanical Technology, Inc., Latham, NY.
COMPUTER-ASSISTED STRAIN-GAGE MONITORING AND DATA REDUCTION SYSTEM Final Report, Jul. 1985 - May 1990
LAWRENCE LAGACE and PETER HAYES Aug. 1990 63 p
(Contract F33615-85-C-2503; AF PROJ. 3066)
(AD-A226894; MTI-89TR19; WRDC-TR-90-2064) Avail: NTIS HC/MF A04 CSCL 09/1

The objective of this program was to design and build a computer-based strain gage monitoring system (SGMS) for the Wright-Patterson Air Force Base (WPAFB) using state-of-the-art electronics to assist in real-time monitoring and subsequent reduction and analysis of compressor analog data. During aerodynamic and aeromechanical testing at the WPAFB Compressor Research Facility (CRF), the SGMS monitors blade and vane stress level data provided by sensors attached to a turbine engine compressor. The system monitors vibratory responses, provides ample warning of compressor component failure, and assists test engineers in data analysis. On-line data are presented to the test engineers via a graphics display terminal and printed reports. GRA

N91-14608* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
TURBOMACHINERY ROTOR SUPPORT WITH DAMPING Patent
GEORGE L. VONPRAGENAU, inventor (to NASA) 22 May 1990 8 p Filed 26 May 1989
(NASA-CASE-MFS-28345-1; US-PATENT-4,927,326; US-PATENT-APPL-SN-364743; US-PATENT-CLASS-415-170.1; US-PATENT-CLASS-415-174.5; US-PATENT-CLASS-415-229; INT-PATENT-CLASS-F01D-11/08) Avail: US Patent and Trademark Office CSCL 13/9

Damping seals, damping bearings, and a support sleeve are presented for the ball bearings of a high speed rotor. The ball bearings consist of a duplex set having the outer races packaged tightly within the sleeve while the sleeve provides a gap with a support member so that the bearings may float with the sleeve. The sleeve has a web extending radially between the pair of outer races and acts in conjunction with one or more springs to apply an axial preload to the outer races. The sleeves have a series of slits which provide the sleeve with a spring-like quality so that the spring acts to center the rotor upon which the bearings are mounted during start up and shut down. A damping seal or a damping bearing may be used in conjunction with the ball bearings and supporting sleeve, the damping seal and damping bearing having rotor portions including rigid outer surfaces mounted within the bore of a stator portion having triangular shaped pockets on the surface facing the rotor. Axial gates are provided between adjacent pockets in sections of the stator permitting fluid to flow with less resistance axially relative to the flow of fluids circumferentially between the rotor and the stator.
Official Gazette of the U.S. Patent and Trademark Office

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A91-19247#
REMOTE MEASUREMENTS OF SUPERCOOLED INTEGRATED LIQUID WATER AND HIGH RESOLUTION RICHARDSON NUMBER DURING WISP/FAA AIRCRAFT ICING PROGRAM
B. B. STANKOV, E. R. WESTWATER, J. B. SNIDER, and R. L. WEBER (NOAA, Wave Propagation Laboratory, Boulder, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract DTFA01-90-Z-02005)
(AIAA PAPER 91-0351)

During February and March 1990, the National Center for Atmospheric Research, NOAA Wave Propagation Laboratory, and NOAA Forecast Systems Laboratory conducted the Winter Icing and Storms Project (WISP). Arrays of microwave radiometers, infrared radiometers, lidar ceilometers, radio-acoustic sounding systems, and wind profilers were used to determine spatial and temporal distribution of supercooled liquid water. Results are presented from three representative cases to demonstrate that the integrated system that comprises a microwave water substance radiometer, a radio-acoustic sounding system, and a ceilometer can identify supercooled liquid water, and that the integrated system that comprises the high resolution wind profiler and the radio-acoustic sounding system can identify the distribution of turbulent air pockets within the aircraft icing cloud. Author

A91-19248#
AN ASSESSMENT OF THE ONE-DIMENSIONAL ICING FORECAST MODEL APPLIED TO STRATIFORM CLOUDS
ARNOLD TUNICK and HENRY RACHELE (U.S. Army, Atmospheric Sciences Laboratory, White Sands Missile Range, NM) AIAA,

Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 6 p. refs
(AIAA PAPER 91-0352)

Aircraft icing can seriously impair aircraft performance. In this paper a one-dimensional icing forecast model (presently residing at the U.S Army Atmospheric Sciences Laboratory) by using microphysics data collected by Jeck (1983) is presented. Prime interest was the variation of potential aircraft icing in stratiform clouds. The icing model microphysics are discussed, including an algorithm used to determine icing severity indices, and modern data such as temperature, liquid water content (LWC), and median volume diameter of supercooled water droplets. Output from the one-dimensional model suggests that the icing potential in stratiform clouds does not exceed 'light' and more often forecasts 'trace' icing for both fixed-wing aircraft and helicopters. The model does not compute a value for LWC great enough to allow for more serious icing events. Therefore, it is concluded that a method must be established to obtain better estimates of drop-size characteristics and LWC (for stratus clouds) to forecast the full range of potential icing for Army aircraft. Otherwise, when using the one-dimensional model as currently structured, one would not expect any more than 'light' icing when stratus clouds are observed. Author

A91-19249#
CONDITIONS ASSOCIATED WITH LARGE DROP REGIONS
BRENDA POBANZ and JOHN D. MARWITZ (Wyoming, University, Laramie) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 3 p. Research supported by the U.S. Department of the Interior.
(AIAA PAPER 91-0353) Copyright

This paper investigates the conditions associated with and leading to large drop regions. Along with warm cloud top temperatures, and low droplet concentrations, it is hypothesized that wind shear at the top of the cloud is vital as it may cause Kelvin-Helmholtz waves and hence inhomogeneous mixing. An example situation is shown to be in accordance with this theory. Author

A91-19305#
WAVELET ANALYSIS OF GUST STRUCTURE IN MEASURED ATMOSPHERIC TURBULENCE DATA
J. G. JONES, P. G. EARWICKER (Royal Aerospace Establishment, Farnborough, England), G. W. FOSTER (Royal Aerospace Establishment, Bedford, England), and G. H. WATSON (SD-Scicon, /UK/ Ltd., Farnborough, England) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0448) Copyright

A method for analyzing atmospheric turbulence data is described, in the form of a wavelet analysis which extracts localized structure in the form of discrete ramp-shaped gusts. A two-dimensional correlation surface is generated, the independent variables being position and scale, and discrete gusts are detected by the identification of peaks in this correlation surface which, formally, is equivalent to the invertible Wavelet Transform. The method is illustrated by application to measured turbulence records. Implications of the results for aircraft design criteria, particularly for structural loads and load-alleviation control systems, are discussed. Author

15

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A91-17115
DEVELOPMENT OF COMPUTER-ORIENTED MEANS OF NOMOGRAM PROCESSING FOR SOLVING AERODYNAMICS PROBLEMS DURING PREFLIGHT AIRCRAFT PREPARATION [RAZRABOTKA MASHINNO-ORIENTIROVANNYKH SREDSTV OBRABOTKI NOMOGRAMM DLIA RESHENIIA ZADACH AERODINAMIKI PRI PODGOTOVKE SAMOLETA K POLETU]
O. V. ZHUK, N. A. LEVCHENKO, V. P. ZINCHENKO, and A. A. ERMOLENKO *Samoletostroenie - Tekhnika Vozdushnogo Flota* (ISSN 0581-4634), no. 56, 1989, p. 64-68. In Russian.
Copyright

The paper is concerned with some theoretical and practical aspects of the development of a complex of computer-oriented tools for the processing of nomograms required for the efficient determination of the take-off and landing characteristics of aircraft. In particular, attention is given to the development of a mathematical model for nomogram processing and efficient methods for determining its optimal parameters. The relative error of the computational algorithms based on the model described here does not exceed 2 percent. V.L.

A91-17245
THE ROLE OF MISSION/TASK ANALYSIS IN REDUCING WEAPON SYSTEM COSTS AND RISKS
THEODORE B. ALDRICH, BRUCE E. HAMILTON (Sikorsky Aircraft, Stratford, CT), and SANDRA M. SZABO (CAE-Link Corp., Binghamton, NY) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 619-629. refs
Copyright

This paper describes current and proposed applications of the Army's Task Analysis Workload (TAWL) prediction methodology. The methodology was first applied during the Advanced Rotorcraft Technology Integration (ARTI) program to estimate operator mental workload associated with varying degrees of automation for one- and two-crewmember Light Helicopter Experimental (LHX) configurations. Workload estimates produced by the methodology also were used to guide tradeoffs between development risks and program costs. Currently, the Boeing-Sikorsky First Team is using a refinement of TAWL as an analysis tool in the implementation of the Army's Manpower and Personnel Integration (MANPRINT) Program. The refined TAWL is being used to predict operator workload, to document crew station design requirements, to assess operator workload in conjunction with full mission simulation, and to guide training system development. Proposed innovative applications of TAWL include assisting in the determination of processor throughput requirements and the allocation of software resources. Author

A91-17247
USING HYPERCARD IN CREWSTATION DESIGN - BEYOND RAPID PROTOTYPING
PATRICIA A. CASPER (Sikorsky Aircraft, Stratford, CT) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 645-648.
Copyright

This paper describes the application of a commercially available software program to advanced helicopter cockpit design. This software has been effective in helping the designer evaluate and revise early iterations of his work, by allowing early assessments of the system's functionality and the identification of unforeseen

pilot-crewstation interaction problems. The tool has proved useful in making early design decisions that avoid the expense and time delays associated with implementing a full- or part-mission simulation. In addition, the tool shows further promise as a desktop crewstation training device, in which a user can access system information in a Hypermedia environment as he or she is learning to operate the system. Author

A91-17249
COMPUTER AIDED REFLECTION ANALYSIS
ROBERT M. BEGGS (Boeing Helicopters, Philadelphia, PA) and JOHN SAWAYA (Boeing Computer Services, Philadelphia, PA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 655-661.
Copyright

A computer based approach has been developed to predict cockpit reflections, which eliminates the need for physical mockups for this task. The program is implemented in CATIA, a three-dimensional CADCAM system . The paper is not limited to the CATIA application of reflection prediction alone, but also examines the mathematics and general principles of reflection. Author

A91-17599
FLO87 ON THE IPSC/2 - A PARALLEL MULTIGRID SOLVER FOR THE EULER EQUATIONS
G. CHESSHIRE (Intel Scientific Computers, Beaverton, OR) and A. JAMESON (Princeton University, NJ) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton, England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 79-88. refs
Copyright

FLO87 uses explicit finite-volume methods to find steady solutions to the Euler equations for transonic aerodynamic flow. A sequence of steady solutions is found for a given problem on successively finer grids; the solution to each provides the initial state for the next. The multigrid method is used for each sub-problem to accelerate convergence to a steady solution. The computational domain for FLO87, a rectangular three-dimensional grid, is decomposed on the iPSC/2 into a grid of identical subgrids, one per processor, with one plane of overlap for each face of a sub-grid. The only communication needed between processors is for transfer of the solution between adjacent faces of sub-grids and for global commutative operations. Due to the high ratio of computation to communication and the regularity of the domain, this algorithm obtains good load balance and high parallel efficiency on the iPSC/2. Author

A91-17972
ROBUST VARIABLE STRUCTURE CONTROL OF MODEL REFERENCE SYSTEMS
S. K. SPURGEON (Loughborough University of Technology, England) and R. J. PATTON (York, University, England) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 137, pt. D, no. 6, Nov. 1990, p. 341-348. refs
Copyright

Model-following as used in variable structure control system (VSCS) design is presented. The procedure uses a model with ideal response characteristics and assumes that the error between the plant and the model is of sliding type. To achieve the desired performance a parameter-insensitive controller with improved disturbance rejection is used. The robustness of the nonlinear control scheme is assessed by applying the resulting VSCS to a range of perturbation models of the fully nonlinear aircraft model. B.P.

A91-19024#
SYSTEM FAILURE ISOLATION IN DYNAMIC SYSTEMS
DAN T. HORAK (Allied-Signal Aerospace Co., Columbia, MD) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1075-1082. refs
Copyright

This paper presents an analysis and a systematic solution to the problem of system failure isolation in dynamic systems. System failures are related to the system matrix of a dynamic model and they change the dynamic response of the system. Failure isolation is concerned with specifying the type, size, and location of failures, following their detection. Two system failure isolation algorithms are proposed, one for failures that can be modeled as changes of parameters of the system matrix and the other for failures that do not have a simple model. The two algorithms working in parallel form a method capable of isolating system failures of either type. A flight control example and a jet engine example are used to illustrate the method. Author

A91-19040*# Minnesota Univ., Minneapolis.
GENERALIZED GRADIENT ALGORITHM FOR TRAJECTORY OPTIMIZATION
YIYUAN ZHAO (Minnesota, University, Minneapolis), A. E. BRYSON, and R. SLATTERY (Stanford University, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1166-1169. refs
(Contract NAG2-191)
Copyright

The generalized gradient algorithm presented and verified as a basis for the solution of trajectory optimization problems improves the performance index while reducing path equality constraints, and terminal equality constraints. The algorithm is conveniently divided into two phases, of which the first, 'feasibility' phase yields a solution satisfying both path and terminal constraints, while the second, 'optimization' phase uses the results of the first phase as initial guesses. O.C.

A91-19127*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
A RIGOROUS TESTING METHODOLOGY FOR CONTROL SYSTEMS
ANDREW W. LEWIN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by NASA.
(AIAA PAPER 91-0085) Copyright

This paper discusses the development of a generalized verification testing methodology as applied to control systems. The methodology is based upon determining inputs that rigorously test each element of a system in order to verify that it has been specified properly. The methodology was successfully applied to testing of Boeing 737 autoland control system. Author

A91-19292#
PARAMETER ADAPTIVE MULTIVARIABLE FLIGHT CONTROLLER USING A FULL AUTOREGRESSIVE MOVING AVERAGE (ARMA) MODEL AND RECURSIVE LEAST SQUARES (RLS) ESTIMATION
DARYL HAMMOND and JOHN J. D'AZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0420)

The paper demonstrates the feasibility of implementing an adaptive controller when aircraft dynamics are expressed in the form of a discrete ARMA representation and the PI control law gain calculations are based on these values. It is found that the recursive least squares parameter estimation algorithm is compatible with the PI control law. By minimizing the coupling of the outputs, it is possible to optimize the fast tracking characteristics of the PI controller. K.K.

A91-19332#
THE USE OF KNOWLEDGE-BASED SYSTEMS FOR AERODYNAMICS TECHNOLOGY TRANSFER
L. C. RODMAN, D. NIXON, T. N. CANNING (Nielsen Engineering and Research, Inc., Mountain View, CA), J. G. HUGHES (Ulster, University, Northern Ireland), and P. BRADSHAW (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno,

NV, Jan. 7-10, 1991. 9 p. Research supported by Nielsen Engineering and Research, Inc.
(AIAA PAPER 91-0500) Copyright

A knowledge-based system for the transfer of aerodynamics technology is described in this work. The purpose of this system is to familiarize engineering managers or design engineers with state-of-the-art research knowledge. The prototype system developed covers the topic of the diagnosis of a low-speed low-turbulence wind-tunnel design. Through an interactive rule base, the program determines whether a preliminary design is satisfactory. The system also includes a tutorial, which provides a description of the issues that influence design decisions as well as selected references to the literature. If further information is desired, the user can study a specific tunnel component in great detail, moving through levels of knowledge that eventually reach the basic underlying fluid mechanics at a depth that signifies the current research state. Author

A91-19333#
INTEGRATING NUMERIC AND SYMBOLIC PROCESSING FOR GAS PATH MAINTENANCE
HOWARD WINSTON, DAVID SIRAG, THOMAS HAMILTON, HOWARD SMITH, DAN SIMMONS (United Technologies Research Center, East Hartford, CT) et al. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0501) Copyright

An object-oriented software system has been developed that integrates numeric and symbolic processing to verify and enhance an engine analyst's ability to diagnose gas path problems. The system uses data from pre- or post-repair engine performance analysis, diagnoses the possible engine fault, and recommends cost-effective remedial actions. The numerical techniques normalize test cell operating conditions and provide fine-grained engine module performance data. The symbolic processing automates an expert's judgment and interpretation of the results based on heuristics, historical experience, and common sense reasoning about the operation of the gas path. Author

A91-19449#
FRACTIONAL CALCULUS - A NEW APPROACH TO MODELING UNSTEADY AERODYNAMIC FORCES
RONALD L. BAGLEY (USAF, Institute of Technology, Wright-Patterson AFB, OH), DAVID V. SWINNEY (USAF, Space Systems Div., Los Angeles, CA), and KENNETH E. GRIFFIN (USAF, National Aerospace Plane Joint Program Office, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0748)

Fractional order time derivatives are used to construct an accurate global s-plane approximation of the Theodorsen function representation for two-dimensional unsteady aerodynamic forces. The resulting fractional derivative approximation is mathematically compact and appropriate for both stability analysis and control system design. A fractional derivative representation of the downwash kernel for a wing with finite span is also shown, identifying fractional calculus as an excellent candidate for describing three-dimensional unsteady aerodynamic forces. Author

A91-19469#
ADVANCED AERODYNAMIC APPLICATIONS OF AN INTERACTIVE GEOMETRY AND VISUALIZATION SYSTEM
W. K. CAPRON and K. L. SMIT (Boeing Commercial Airplane Group, Seattle, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0800) Copyright

This paper presents advanced aerodynamic applications of an interactive geometry and visualization system. The system, called AGPS (Aerodynamic Grid and Paneling System), is described, and its role in computational fluid dynamics (CFD) at Boeing is summarized. AGPS is used to define geometry, determine grid, and display graphics in support of CFD. Recent advances are described including developing a portable version of the code, new techniques for representing grids for CFD, and advanced graphical displays and visualization capabilities. The versatility of AGPS is highlighted by presenting a variety of nontraditional applications. Author

A91-19588
POSTPROCESSING TOOLS FOR AERODYNAMIC CALCULATIONS [DES OUTILS DE POST-TRAITEMENT DE CALCUL EN AERODYNAMIQUE]
F. BARTAK, D. BEGIS, J. M. CHANTREL (Simulog, Saint-Quentin-en-Yvelines, France), and PH. DEWAGENAERE (Electricite de France, Chatou) AAAF, Colloque d'Aerodynamique Appliquee, 26th, Toulouse, France, Oct. 23-25, 1989. 20 p. In French.
(AAAF PAPER NT 89-20) Copyright

The numerical methods utilized to solve industrial aerodynamics problems provide engineers with a mass of numerical data such as velocities, temperatures, pressures, and Mach numbers. A software program, SIMULOG, that performs the analysis and display of the numerical simulation results is presented. The various functions used for data processing and algorithms in the TIGRE software, a general postprocessing tool, and PABLO, a tool used for numerical fluid-mechanics models employing the finite difference method, are described. R.E.P.

N91-13938# Naval Postgraduate School, Monterey, CA.
APPLICATIONS OF NEURAL NETWORKS TO ADAPTIVE CONTROL M.S. Thesis
RUSSELL W. SCOTT, II Dec. 1989 117 p
(AD-A225408) Avail: NTIS HC/MF A06 CSCL 23/3

The amount of a priori knowledge required to design some modern control systems is becoming prohibitive. Two current methods addressing this problem are robust control, in which the control design is insensitive to errors in system knowledge, and adaptive control, in which the control law is adjusted in response to a continually updated model of the system. This thesis examines the application of parallel distributed processing (neural networks) to the problem of adaptive control. The structure of neural networks is introduced, focusing on the Backpropagation paradigm. A general form of controller consistent with use in neural networks is developed and combined with a discussion of linear least squares parameter estimation techniques to suggest a structure for neural network adaptive controllers. This neural network adaptive control structure is then applied to a number of estimation and control problems using as a model the longitudinal motion of the A-4 aircraft. The purpose of this thesis is to develop and demonstrate a neural network adaptive control structure consistent with adaptive control theory. GRA

N91-13947# Loughborough Univ. of Technology (England). Dept. of Mathematical Sciences.
ROBUST VARIABLE STRUCTURE CONTROL OF MODEL REFERENCE SYSTEMS
S. K. SPURGEON and R. J. PATTON (York Univ., England) Aug. 1990 29 p
(MATHS-REPT-A-131; ETN-91-98352) Avail: NTIS HC/MF A03

A VSCS (Variable Structure Control System) design approach is used to create a system which exhibits parameter insensitivity with good disturbance rejection whilst allowing all command inputs, including those which act within the nominal input channels. Given a model with ideal response characteristics, the discontinuity surfaces are chosen to render the sliding dynamic mode minimally sensitive to those parameter variations which do not act within the nominal input channels. The possibility of forcing the error between the plant and model to zero and to ensure that the error system attains a sliding mode is demonstrated. It is proved that eigenstructure assignment can be used to modally shape a desired system response and so determine an ideal model while the pilot demand can be incorporated as a model input. ESA

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A91-17001
DYNAMICS OF CONTROL SYSTEMS [DINAMIKA SISTEM UPRAVLENIIA]
V. I. ZUBOV, ED. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, 208 p. In Russian. For individual items see A91-17002 to A91-17009.
Copyright

Papers are presented on mathematical methods for the analysis of control systems for technical plants and manufacturing processes. Particular attention is given to the mechanics of controlled space flight, the design of automatic control systems, flexible automated complexes, control applications in biomedical research, and chemical technology for the production of new types of materials. B.J.

A91-17223* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CAN SHOCK WAVES ON HELICOPTER ROTORS GENERATE NOISE? - A STUDY OF THE QUADRUPOLE SOURCE
F. FARASSAT (NASA, Langley Research Center, Hampton, VA) and H. TADGHIGHI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 323-346. refs
Copyright

An analysis has previously established that local shock surfaces attached to helicopter rotor blades moving at high subsonic speeds are potent noise generators; in pursuit of this insight, a novel formulation is presented for the prediction of the noise of a deformable shock, whose area changes as a function of the azimuthal position of the blade. The derivation of this formulation has its basis in a mapping of the moving shock to a time-independent region. In virtue of this mapping, the implementation of the main result on a computer becomes straightforward enough for incorporation into the available rotor-noise prediction code. A problem illustrating the importance of rotor shocks in the generation of high-intensity noise is presented. O.C.

A91-17224* Army Aviation Systems Command, Moffett Field, CA.
THE ACOUSTIC RESULTS OF A UNITED TECHNOLOGIES SCALE MODEL HELICOPTER ROTOR TESTED AT DNW
SANDY R. LIU (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and MICHAEL A. MARCOLINI (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 347-366. Previously announced in STAR as N90-27471. refs
Copyright

In a major cooperative program between U.S. Government agencies (represented by the U.S. Army Aeroflightdynamics Directorate and NASA Ames and Langley Research Centers) and United Technologies Corp., a 1/6 geometrically and aeroelastically scaled UTC model helicopter rotor was tested in the open-jet anechoic test section of the Duits-Nederlandse Windtunnel in the Netherlands. As the fourth entry under the Aerodynamic and Acoustic Testing of Model Rotors Program, several comprehensive acoustic and aerodynamic databases were obtained relating the important aerodynamic phenomena to both the near- and far-field acoustic radiation. In particular, high speed impulsive noise and blade-vortex interaction are of primary interest. This paper provides an initial summary of the acoustic measurements acquired for some of the different configurations tested. A review of the baseline swept tip rotor acoustic characteristics in the regimes of high speed forward flight, where high speed impulsive noise dominates, and low speed descent, where severe blade vortex interaction noise occurs, is presented. The trends of these primary noise sources are studied as the first step in validating the data for release and application. Author

A91-17225* McDonnell-Douglas Helicopter Co., Mesa, AZ.
PREDICTION OF BLADE-VORTEX INTERACTION NOISE USING AIRLOADS GENERATED BY A FINITE-DIFFERENCE TECHNIQUE
HORMOZ TADGHIGHI, AHMED A. HASSAN, and BRUCE CHARLES (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 367-378. refs
(Contract NAS1-17145)
Copyright

The present numerical finite-difference scheme for helicopter blade-load prediction during realistic, self-generated three-dimensional blade-vortex interactions (BVI) derives the velocity field through a nonlinear superposition of the rotor flow-field yielded by the full potential rotor flow solver RFS2 for BVI, on the one hand, over the rotational vortex flow field computed with the Biot-Savart law. Despite the accurate prediction of the acoustic waveforms, peak amplitudes are found to have been persistently underpredicted. The inclusion of BVI noise source in the acoustic analysis significantly improved the perceived noise level-corrected tone prediction. O.C.

A91-17640#
XV-15 TILTROTOR AIRCRAFT NOISE CHARACTERISTICS
BRYAN D. EDWARDS (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 9 p. refs

This paper describes the most recent noise test of the XV-15 tiltrotor aircraft which, in addition to level-flight studies of airspeed and nacelle angle, includes takeoff and landing flight procedures representative of those that might be used in vertiport operations. The paper first reviews basic tiltrotor noise characteristics, defining modes of tiltrotor flight that affect the noise generated, then applies the quiet operating modes to realistic takeoff and landing operations to define their effect upon noise exposure near a vertiport. This effect is illustrated for the XV-15 in the form of day-night level contours, initially assuming 50 takeoff and landing operations per day. These XV-15 contours are then extrapolated to approximate the noise of a civil variant of the larger V-22 Osprey tiltrotor for up to 200 operations per day. Author

A91-17641*# Cornell Univ., Ithaca, NY.
ANALYSIS AND PREDICTION OF TILT ROTOR HOVER NOISE
CHARLES D. COFFEN and ALBERT R. GEORGE (Cornell University, Ithaca, NY) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 13 p. refs
(Contract NAG2-554)

This paper presents new and improved tilt rotor hover noise prediction methods. Calculations include both discrete frequency harmonic noise and broadband noise mechanisms due to the ground plane/fountain recirculating flow. The noise mechanisms studied are thickness, loading, and inflow turbulence noise. In each case aeroacoustic models are developed and compared to noise measurements obtained experimentally for the XV-15 experimental tilt rotor aircraft. Both the effects of the mean and the turbulent fountain flows are found to be important noise sources and have strongly directional radiation patterns toward the rear of the aircraft (the direction of the rotor motion through the fountain flow). Calculations also show that the noise generated by the inflow of ambient atmospheric turbulence can also be an important noise source in hover in some directions. Further development of the methods and models, and precise information about the fountain

flow, are needed to improve the predictions and to initiate noise minimization studies. Author

A91-17642#
NOISE MECHANISMS OF TRANSONIC BLADE-VORTEX INTERACTIONS
A. S. LYRINTZIS and Y. XUE (Minnesota, University, Minneapolis) AHS, Annual Forum and Technology Display, 46th, Washington, DC, May 21-23, 1990, Paper. 13 p. Research supported by the University of Minnesota. refs

Transonic Blade-Vortex Interactions (BVI) are simulated numerically and the noise mechanisms are investigated. The two-dimensional high frequency transonic small disturbance equation is solved numerically (VTRAN2 code). An ADI scheme with monotone switches is used, viscous effects are included on the boundary and the vortex is simulated by the cloud-in-cell method. The Kirchhoff method is used for the extension of the numerical two-dimensional near-field aerodynamic results to the linear acoustic three-dimensional far-field. The effect of the different type of shock motion is investigated. Two different important disturbances with different directivity exist in the pressure signal and are believed to be related to the fluctuating lift and drag forces. Noise directivity for different cases is shown. The maximum radiation occurs at an angle around 30 deg below the horizontal for a vortex-fixed coordinate system. Author

A91-18257*# Sverdrup Technology, Inc., Brook Park, OH.
PREDICTION OF UNSTEADY BLADE SURFACE PRESSURES ON AN ADVANCED PROPELLER AT AN ANGLE OF ATTACK
M. NALLASAMY (Sverdrup Technology, Inc., Brook Park, OH) and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, Sept. 1990, p. 789-803. Previously cited in issue 17, p. 2684, Accession no. A89-40473. refs
(Contract NAS3-25266)
Copyright

A91-19175#
INFLUENCE OF A NON-UNIFORM FREE STREAM VELOCITY DISTRIBUTION ON PERFORMANCE/ACOUSTICS OF COUNTERROTATING PROPELLER CONFIGURATIONS
C. S. ALLEN and K. D. KORKAN (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0195) Copyright

A methodology for predicting the performance and acoustics of counterrotating propeller configurations was modified to take into account the effects of a non-uniform free stream velocity distribution entering the disk plane. The method utilizes the analytical techniques of Lock and Theodorson as described by Davidson to determine the influence of the non-uniform free stream velocity distribution in the prediction of the steady aerodynamic loads. The unsteady load contribution is determined according to the procedure of Leseture with rigid helical tip vortices simulating the previous rotations of each propeller. The steady and unsteady loads are combined to obtain the total blade loading required for acoustic prediction employing the Ffowcs Williams-Hawking equation as simplified by Succi with the assumption of compact sources. The numerical method is used to redesign the previous commuter class counterrotating propeller configuration of Denner. The specifications, performance, and acoustics of the new design are compared with the results of Denner thereby determining the influence of the non-uniform free stream velocity distribution on these metrics. Author

A91-19328*# Florida State Univ., Tallahassee.
RELATIONSHIP BETWEEN THE INSTABILITY WAVES AND NOISE OF HIGH-SPEED JETS
CHRISTOPHER K. W. TAM (Florida State University, Tallahassee), J. M. SEINER (NASA, Langley Research Center, Hampton, VA), and PING CHEN AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract NAG1-421)
(AIAA PAPER 91-0492) Copyright

The relationship between the instability waves and noise of hot jets at moderate supersonic Mach number is investigated. The relative importance of the Kelvin-Helmholtz instability waves and the supersonic instability waves as sources of noise is considered. The results show that, for the range of Mach number and jet-to-ambient temperature ratio considered, the Kelvin-Helmholtz instability waves have much higher total amplification and higher phase speed. K.K.

A91-19329*# Nielsen Engineering and Research, Inc., Mountain View, CA.
JET NOISE PREDICTIONS FROM UNSTEADY NAVIER-STOKES SIMULATIONS
ROBERT E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA), WILLIAM W. BOWER, GERALD E. CHMIELEWSKI (McDonnell Douglas Research Laboratories, Saint Louis, MO), and MICHAEL S. HOWE (BBN Systems and Technologies Corp., Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(Contract NAS1-18745)
(AIAA PAPER 91-0493) Copyright

Numerical solutions of the Navier-Stokes equations are employed to predict the characteristics of round jets at supersonic speeds. The simulations are performed with a finite volume method which is fourth order accurate in space and second order in time. The overall sound pressure level (OASPL) in the near field of a round free jet is over-predicted by roughly 8 dB relative to an experimental correlation. In an impinging jet, shock motion and vortex stretching are identified as noise generation mechanisms in the impingement zone. Author

A91-19331*# Lockheed Engineering and Sciences Co., Hampton, VA.
ACTIVE SOUND ATTENUATION ACROSS A DOUBLE WALL STRUCTURE
FERDINAND W. GROSVELD (Lockheed Engineering and Sciences Co., Hampton, VA) and KEVIN P. SHEPHERD (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0498) Copyright

The possibility of achieving significant local and global sound attenuation across a flat double wall is demonstrated. It is also shown that sound can be prevented from entering the interior of a cabinlike environment. The approach used is unlike established active noise control techniques. K.K.

A91-19376*# Continuum Dynamics, Inc., Princeton, NJ.
GENERAL FLOW FIELD ANALYSIS METHODS FOR HELICOPTER ROTOR AEROACOUSTICS
TODD R. QUACKENBUSH, C. GORDON LAM (Continuum Dynamics, Inc., Princeton, NJ), and DONALD B. BLISS (Duke University, Durham, NC) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(Contract NAS1-19023)
(AIAA PAPER 91-0591) Copyright

Previous work in the analysis of rotor flow fields for aeroacoustic applications involved the preliminary development of an efficient and accurate Lagrangian simulation of the unsteady vorticity field in the vicinity of helicopter main rotor that could analyze a limited class of rotor/wake interactions. The capabilities of this analysis have subsequently been considerably enhanced to allow it to serve as the foundation for a general analysis of the rotor/wake interaction noise. This paper presents the details of these enhancements, which focus on the expansion of the reconstruction approach developed previously to handle arbitrary vortex wake interactions within three-dimensional regions located near or within the rotor disk. Also, the development of nearfield velocity corrections appropriate for the analysis of such interactions is described, as is a preliminary study of methods for using the new high-resolution flow field analysis for noise predictions. The results show that by employing this novel flow field reconstruction

technique it is possible to employ full-span free wake analyses with temporal and spatial resolution suitable for acoustic applications while reducing the computation time required by one to two orders of magnitude relative to traditional methods.
Author

A91-19330
DEVELOPMENT OF FLY-BY-LIGHT SYSTEMS
JOHN R. TODD (Douglas Aircraft Co., Long Beach, CA) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 139-146.
Copyright
The driving factors for the development of fly-by-light systems, tradeoffs, and some design guidelines for the selection and implementation of fiber optic systems on aircraft are presented. Applications of fly-by-light systems are outlined, and areas requiring further development for fiber optics on aircraft are pointed out. Fiber optic projects at one company are discussed. C.D.

A91-20014
SHOCK WAVE GENERATION BY TRANSONIC VORTEX-PROFILE INTERACTION [STOSSWELLENENTSTEHUNG BEI TRANSSONISCHER WIRBEL-PROFIL-WECHSELWIRKUNG]
G. E. A. MEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany), U. SCHIEVELBUSCH, and H.-M. LENT Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, Oct. 1990, p. 327-332. In German. refs
Copyright
Two impulse noise generation mechanisms, parallel interaction between a vortex and an airfoil in two-dimensional airflow, are investigated experimentally. The first one originates from the area of the stagnation point of the airfoil. When the vortex rotates toward the airfoil, the pressure and the density increase at the stagnation point while the vortex is passing. The pressure then decreases with the emission of a sound wave propagating upstream, called a compressibility wave. The second observed source of impulse noise is the shock generated by the decay of a local supersonic flow regime. This unsteady supersonic flow regime is induced by the vortex flow near the leading edge of the airfoil. After the vortex has passed the leading edge, the shock at the end of the supersonic flow regime propagates upstream. This kind of shock generation, called transonic wave generation, is determined by the vortex-induced Mach number. Author

N91-13969# Florida State Univ., Tallahassee. Dept. of Mathematics.
COMPUTATION OF BROADBAND MIXING NOISE FROM TURBOMACHINERY Semiannual Progress Report, 1 Mar. - 31 Aug. 1990
CHRISTOPHER TAM 31 Aug. 1990 2 p
(Contract N00014-89-J-1836)
(AD-A226559) Avail: NTIS HC/MF A01 CSCL 20/1
This paper discusses the phenomena of dispersion and spurious acoustic radiation in calculating propeller noise using finite difference approximation. Dispersion effect here is global in nature and could cause large distortion of the radiated acoustic waveform as the waves propagate away from the propeller. GRA

N91-14030# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
APPLICATIONS OF SUPERCONDUCTIVITY TO AVIONICS
Oct. 1990 164 p Meeting held in Bath, England, 7-8 May 1990
(AGARD-CP-481; ISBN-92-835-0586-7; AD-A229161) Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
Recent advances in developing high temperature superconductors have renewed interest in the entire superconductivity field. Modern techniques in materials preparation are making it possible to fabircate a number of new superconducting components which promise significant improvements in the performance of avionics systems. The almost daily revelation of advances in this area attests to its importance as an emerging technology. Device scientists and avionics engineers explore the possibilities for exploiting all aspects of superconductivity in avionics systems.

N91-14047# Varian Associates, Palo Alto, CA.
A LIQUID NITROGEN COOLED SUPERCONDUCTIVE ELECTRON BEAM FOCUSING SYSTEM FOR IMPROVED PERFORMANCE ECM HELIX TRAVELING WAVE TUBES
M. C. GREEN *In* AGARD, Applications of Superconductivity to Avionics 6 p Oct. 1990
Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
In avionics, the focus of attention in recent years has been upon the development of solid state devices for low-level signal processing. Device development based upon the new high-temperature superconductors has mirrored this, with concentration upon thin film systems as a basis for the eventual fabrication of delay lines, resonators and the like. However, large numbers of avionics systems, particularly in the electronic countermeasures (ECM) area, employ traveling wave tubes (TWTs) as final power amplifiers. Broadband ECM helix TWTs utilizing periodic permanent magnet (PPM) focusing systems are particularly suitable for the application of superconductive focusing systems, since despite the relatively low magnetic fields employed along the electron beam axis in a typical PPM stack, the PPM configuration is limited to less-than-optimum axial fields by the local saturation of polepiece material between the adjacent ring magnets of the stack. In a typical I-J band ECM helix TWT, the axial field does not exceed 2.5 KG despite the use of exotic polepiece materials, which in turn means a lower-than-optimum perveance electron beam. This impacts adversely upon TWT bandwidth, stability, and gain. The relatively low field requirement for this application means that a solenoidal field generated by a high-temperature superconductor flux trap is potentially practical with today's level of materials development. Author

N91-14803*# Cornell Univ., Ithaca, NY. Fluid Dynamics and Aerodynamics Program.
PREDICTION OF XV-15 TILT ROTOR DISCRETE FREQUENCY AEROACOUSTIC NOISE WITH WOPWOP
CHARLES D. COFFEN and ALBERT R. GEORGE Jan. 1990 39 p
(Contract NAG2-554)
(NASA-CR-187684; NAS 1.26:187684; FDA-90-10) Avail: NTIS HC/MF A03 CSCL 20/1
The results, methodology, and conclusions of noise prediction calculations carried out to study several possible discrete frequency harmonic noise mechanisms of the XV-15 Tilt Rotor Aircraft in hover and helicopter mode forward flight are presented. The mechanisms studied were thickness and loading noise. In particular, the loading noise caused by flow separation and the fountain/ground plane effect were predicted with calculations made using WOPWOP, a noise prediction program developed by NASA Langley. The methodology was to model the geometry and aerodynamics of the XV-15 rotor blades in hover and steady level flight and then create corresponding FORTRAN subroutines which were used an input for WOPWOP. The models are described and the simplifying assumptions made in creating them are evaluated, and the results of the computations are presented. The computations lead to the following conclusions: The fountain/ground plane effect is an important source of aerodynamic noise for the XV-15 in hover. Unsteady flow separation from the airfoil passing through the fountain at high angles of attack significantly affects the predicted sound spectra and may be an important noise mechanism for the XV-15 in hover mode. The various models developed did not predict the sound spectra in helicopter forward flight. The experimental spectra indicate the presence of blade vortex interactions which were not modeled in these calculations. A need for further study and development of

more accurate aerodynamic models, including unsteady stall in hover and blade vortex interactions in forward flight. Author

17

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-17236
INTEGRATED DESIGN ENVIRONMENT-AIRCRAFT (IDEA) - AN APPROACH TO CONCURRENT ENGINEERING
STEPHEN A. MEYER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1990, p. 509-522. refs
Copyright
The evaluation of the interrelationship between subsystems and design disciplines such as reliability, producibility, maintainability and human factors engineering, and life cycle design criteria during development is an example of the systems approach to design called concurrent engineering. IDEA enables rapid access of disparate design information and establishes a substantiation trail for design decisions, and allows rapid communication of product changes to other members of the development team and provides an efficient, paperless, integrated database for the entire design team to employ during fullscale development. R.E.P.

A91-17284
DIRECT OPERATING COSTS AND THE COST OF MISUNDERSTANDING THEM
BRANDON M. BATTLES (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1047-1052.
Copyright
Few helicopter operators share a common definition of operating costs, and fewer operators understand their actual cost of operations. The fact that few operators understand their actual cost of operations is as bad for an operator's business as is the lack of a clear definition. This paper first discusses the definition of direct operating costs and then demonstrates the importance of understanding actual direct costs of operation. Author

A91-17285
HELICOPTER INSURANCE - AN OVERVIEW
LARRY MATTIELLO (Alpha Aviation Insurance Agency, Inc., Hasbrouck Heights, NJ) IN: AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1990, p. 1053-1055.
Copyright
Premiums for helicopter insurance, as for other aircraft, are influenced by the availability of reinsurance markets, the numbers of new aircraft, and by safety/loss experience, among other factors. This paper reviews these elements, and projects the possibility of a rise in insurance premiums during the early 1990s. Author

A91-19954
FLIGHT SAFETY - POLICE OR PRIVATE ENTERPRISE? [FLUGSICHERUNG - POLIZEI ODER UNTERNEHMEN?]
H. GRAUMANN Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, Sept. 1990, p. 247-255. In German.
Copyright
A comparison is made between the use of police or private enterprise security forces for flight safety. Legal aspects of the choice between public and private security are addressed, including the extent of the potential invasion of privacy posed by the use of either. The thoroughness of the security provided by the police and by private security is examined. C.D.

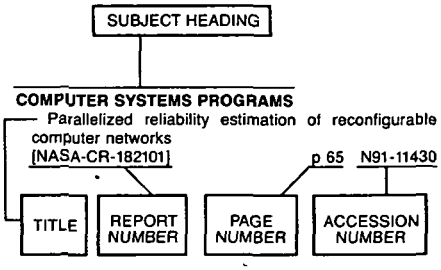
A91-20007
SIXTY YEARS OF THE WARSAW CONVENTION - AIRLINE LIABILITY AT THE CROSSROADS. II
BIN CHENG (Detroit, University, MI) Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, March 1990, p. 3-39.
Copyright
Various articles of the Warsaw Convention are set forth, and comments are made on each which reflect the development of airline liability over the life of the Convention. The purposes of the various protocols, amendments, and new articles that have been added are pointed out. C.D.

A91-20008
POSSIBILITIES OF REFORMING EUROPEAN FLIGHT SAFETY [MOEGLICHKEITEN EINER REFORM DER EUROPAEISCHEN FLUGSICHERUNG?]
MICHAEL BOTHE, HARALD HOHMANN, and CHRISTIAN SCHMIDT Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, March 1990, p. 40-55. In German. refs
Copyright
The problems caused by the decentralization of European air flight safety are reviewed, and the possibilities of reforming the system and creating an overall Eurocontrol are addressed. The structure of such an organization is discussed. The choice between a wholly public organization, a wholly private one, and a mixed one is examined. C.D.

A91-20009
THE DECISION OF THE U.S. SUPREME COURT ON APRIL 18, 1989 IN THE CASE OF CHAN V. KOREAN AIR LINES ON THE LIMITATION OF LIABILITY OF AIR FREIGHT CARRIERS [DIE ENTSCHEIDUNG DES U.S. SUPREME COURT VOM 18. APRIL 1989 IN SACHEN CHAN GEGEN KOREAN AIR LINES ZUR HAFTUNGSBEGRENZUNG DES LUFTFRACHTFUEHRERS]
P. NIKOLAI EHLERS Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, March 1990, p. 56-58. In German.
Copyright
The text of the U.S. Supreme Court decision in Chan et al. v. Korean Air Lines, LTD is presented and briefly discussed. The case involved wrongful death actions against Korean Air Lines (KAL) by survivors of persons killed when one of KAL's aircraft was destroyed by a Soviet aircraft. The decision held that the failure of an airline ticket to present notice of the Warsaw Convention's limitations of per passenger damages for personal injury and death in type no smaller than 10-point did not deprive the airline of the benefit of the damages limitation. C.D.

N91-14080# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD HIGHLIGHTS 90/2, PART 2
Sep. 1990 131 p In ENGLISH and FRENCH Presented at Delegues Nationaux AGARD de l'Industrie Aerospatiale Francaise et du Complexe, Toulouse, France, 29 Mar. 1990
(AD-A226532) Avail: NTIS HC/MF A07; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3
Various aerospace research facilities and/or organizations in the vicinity of Toulouse are discussed. Partial contents are as follows: The Toulouse Research Center and the Fauga-Mauzac Test Center of the French National Aerospace Research Agency (ONERA); Toulouse Aeronautical Test Center of ONERA; Toulouse Research and Studies Center of ONERA; The prime contractor and his subcontractors and subcontracting (A strategic element in Aerospatiale policy); and The Toulouse Space Center. GRA

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

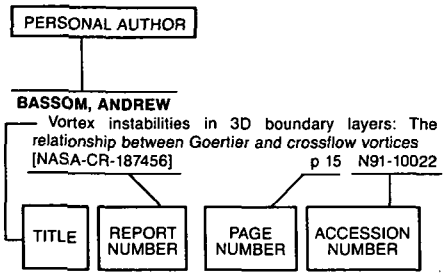
W

X

Y

Z

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

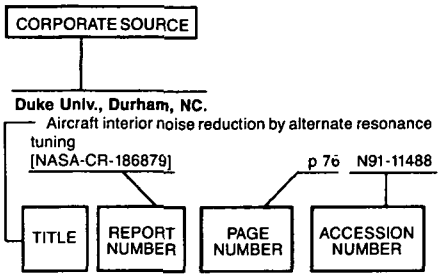
W

X

Y

Z

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

B

C

D

SOURCE

E

F

G

H

I

J

L

M

N

O

P

Q

R

S

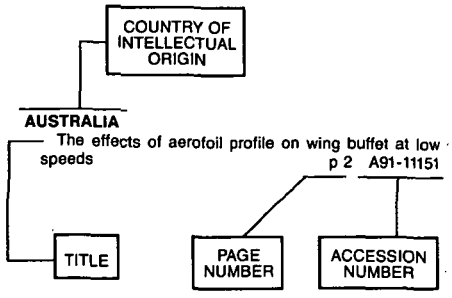
T

U

V

W

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

AUSTRALIA

Fibre composite repairs to damaged structural components p 232 A91-17377

A drag measurement technique for free piston shock tunnels
[AIAA PAPER 91-0549] p 224 A91-19356

Shock tunnel studies of scramjet phenomena, supplement 5
[NASA-CR-182096-SUPPL-5] p 238 N91-13651

C

CANADA

International aspects of civil helicopter operators p 162 A91-17283

NATC Manned Flight Simulator VTOL ship motion simulation and application p 198 A91-17308

Unsteady wind-tunnel interference in dynamic testing
[AIAA PAPER 91-0682] p 179 A91-19410

The IAR high Reynolds number two-dimensional test facility: A description of equipment and procedures common to most 2-D airfoil tests
[AD-A226629] p 184 N91-13409

Wind tunnel investigation and flight tests of tail buffet on the CF-18 aircraft p 218 N91-14325

The effect of wing planform on low speed buffet p 220 N91-14336

CHINA, PEOPLE'S REPUBLIC OF

System reliability of a rotating shaft of an aircraft tailplane p 232 A91-18064

Analytical and experimental investigation of bird impact on blades p 212 A91-20387

Effect of inlet distortion on blade vibration and inlet distortion tolerance p 212 A91-20388

Natural vibration analysis of turbomachinery disk with small mistuned blades p 213 A91-20393

Analysis for typical stator blade structure and its implementation p 238 A91-20396

F

FINLAND

Material degradation of steam turbine rotors in long term operations
[VTT-RR-692] p 230 N91-13530

FRANCE

Validation of a new general Aerospatiale aeroelastic rotor model through the wind tunnel and flight tests data p 195 A91-17227

GPS availability. II - Evaluation of state probabilities for 21 satellite and 24 satellite constellations p 192 A91-17365

Influence of the entropy layer on viscous hypersonic interaction scales p 167 A91-17373

Dynamical behavior of an elastic rotor with squeeze film damper p 232 A91-17870

Modern engineering achievements in the field of automatic fluorescent-penetrant inspection process lines p 233 A91-18536

Eddy current technique for the detection and sizing of fatigue cracks in rivet bore holes on aircraft p 234 A91-18553

Explosives detection raises complex issues p 189 A91-18916

Recent studies on transition and turbulence at ONERA/CERT
[AIAA PAPER 91-0332] p 176 A91-19235

Direct and large-eddy simulations of transitioning and turbulent shear flows
[AIAA PAPER 91-0335] p 176 A91-19237

Postprocessing of experimental and numerical results on two- and three-dimensional shear flow
[AAAF PAPER NT 89-25] p 182 A91-19585

Postprocessing tools for aerodynamic calculations
[AAAF PAPER NT 89-20] p 243 A91-19588

Flow visualization and simulation
[AAAF PAPER NT 89-18] p 237 A91-19589

Methods for detecting and measuring boundary layer transition employed at CERT/DERAT
[AAAF PAPER NT 89-14] p 182 A91-19592

Interaction between a vortex and a profile - Unsteady wall pressure measurements
[AAAF PAPER NT 89-13] p 182 A91-19593

Measurement of the average local density around a model from which a lateral jet issues into supersonic flow
[AAAF PAPER NT 89-08] p 237 A91-19594

The RADAC system for measuring model deformations - First experimental results obtained in the F1 wind tunnel
[AAAF PAPER NT 89-03] p 237 A91-19595

Measurement of the six aerodynamic coefficients in transient flow
[AAAF PAPER NT 89-01] p 182 A91-19596

Applications of Superconductivity to Avionics
[AGARD-CP-481] p 246 N91-14030

AGARD highlights 90/2, part 2
[AD-A226532] p 247 N91-14080

Comparison of different calculation methods applied to a lenticular fuselage section p 186 N91-14293

Aircraft Dynamic Loads Due to Flow Separation
[AGARD-CP-483] p 204 N91-14324

New method to determine in wind tunnel the buffeting forces p 220 N91-14337

Coupled aerodynamic loads due to unsteady stall on a large aspect ratio wing oscillating at great amplitude p 220 N91-14338

G

GERMANY,FEDERAL REPUBLIC OF

MBB's BO 108 design and development p 196 A91-17234

The Franco-German Tiger program - A development status p 196 A91-17235

Computation of downstream flow angles and losses for sub- and transonic turbine cascades flows p 168 A91-17625

Wind effects on helicopter takeoff and landing p 200 A91-18364

Qualification of an eddy current and a radiographic crack inspection for a multilayer aluminium structure p 233 A91-18534

Automated inspection systems for ultrasonic testing of large aircraft components p 234 A91-18554

Ultrasonic field modelling for complex shaped aerospace components p 234 A91-18557

US-inspection of CFRP-laminates with high resolution p 234 A91-18569

Effect of thrust/speed dependence on long-period dynamics in supersonic flight p 201 A91-19039

Application and specification of de-/anti-icing fluids for aircraft with different short takeoff time and rotation speed
[AIAA PAPER 91-0560] p 190 A91-19360

Viscous drag reduction on transport aircraft
[AIAA PAPER 91-0685] p 179 A91-19412

Development of an international standard for de-/anti-icing fluids, procedures and equipment for safe winter operation
[AIAA PAPER 91-0758] p 190 A91-19454

Advances in the development of external 6-component windtunnel balances p 225 A91-19670

Flight safety - Police or private enterprise? p 247 A91-19954

Possibilities of reforming European flight safety p 247 A91-20008

The decision of the U.S. Supreme Court on April 18, 1989 in the case of Chan v. Korean Air Lines on the limitation of liability of air freight carriers p 247 A91-20009

Shock wave generation by transonic vortex-profile interaction p 246 A91-20014

Influence of flow mixing on the performance of a turbofan engine of high by-pass ratio p 212 A91-20015

Analytic formulations of unsteady profile aerodynamics and its application to simulation of rotors
[DLR-FB-90-28] p 184 N91-13415

Influence of thermodynamical modelization for chemically reacting air flow
[MBB/FE122/S/PUB/400] p 184 N91-13418

Systematic investigations of body-wing-tail interference at high angles of attack p 186 N91-14290

Experimental investigation of buffet onset and penetration on a supercritical airfoil at transonic speeds p 219 N91-14328

Experimental investigations of buffet excitation forces on a low aspect ratio trapezoidal half wing in incompressible flow p 219 N91-14329

Experimental investigation and semi-empirical prediction of the dynamic response of a low-aspect-ratio trapezoidal wing due to flow separation p 219 N91-14330

Unsteady aerodynamic forces on an oscillating wing at high incidences and flow separation p 187 N91-14331

I

INDIA

Non-homogeneous track-induced response of vehicles with non-linear suspension during variable velocity runs p 217 A91-17990

Sting corrections to zero-lift drag of axisymmetric bodies in transonic flow p 169 A91-18051

Acoustic emission - Its industrial applications p 233 A91-18551

Accurate method for calculating initial development of vortex sheets p 171 A91-18911

ISRAEL

Advanced helicopter avionics p 205 A91-17219

ITALY

Response of hang gliders to control p 217 A91-18052

Ultrasonic system for in service Non Destructive Inspection of composite structures p 234 A91-18555

J

JAPAN

K

KOREA(SOUTH)

N

NETHERLANDS

P

POLAND

S

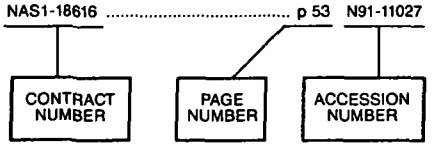
SWEDEN

U

U.S.S.R.

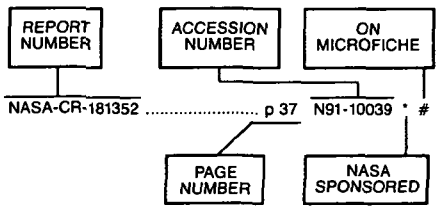
UNITED KINGDOM

Typical Contract Number Index Listing



Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

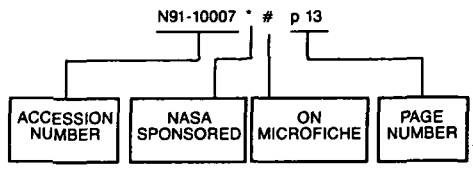
Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

REPORT

Typical Accession Number Index Listing



Listings in this index are arranged alphanumerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

AVAILABILITY OF CITED PUBLICATIONS

IAA ENTRIES (A91-10000 Series)

Publications announced in *IAA* are available from the AIAA Technical Information Service as follows: Paper copies of accessions are available at $10.00 per document (up to 50 pages), additional pages $0.25 each. Standing order microfiche are available at the rate of $1.45 per microfiche for *IAA* source documents and $1.75 per microfiche for AIAA meeting papers.

Minimum air-mail postage to foreign countries is $2.50. All foreign orders are shipped on payment of pro-forma invoices.

All inquiries and requests should be addressed to: Technical Information Service, American Institute of Aeronautics and Astronautics, 555 West 57th Street, New York, NY 10019. Please refer to the accession number when requesting publications.

STAR ENTRIES (N91-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

Avail: NTIS. Sold by the National Technical Information Service. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code preceded by the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on NTIS PRICE SCHEDULES.

Documents on microfiche are designated by a pound sign (#) following the accession number. The pound sign is used without regard to the source or quality of the microfiche.

Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) is available at greatly reduced unit prices. For this service and for information concerning subscription to NASA printed reports, consult the NTIS Subscription Section, Springfield, VA 22161.

NOTE ON ORDERING DOCUMENTS: When ordering NASA publications (those followed by the * symbol), use the N accession number. NASA patent applications (only the specifications are offered) should be ordered by the US-Patent-Appl-SN number. Non-NASA publications (no asterisk) should be ordered by the AD, PB, or other *report number* shown on the last line of the citation, not by the N accession number. It is also advisable to cite the title and other bibliographic identification.

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy. The current price and order number are given following the availability line. (NTIS will fill microfiche requests, as indicated above, for those documents identified by a # symbol.)

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts.* Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on the page titled ADDRESSES OF ORGANIZATIONS.

Avail: Fachinformationszentrum, Karlsruhe. Sold by the Fachinformationszentrum Energie, Physik, Mathematik GMBH, Eggenstein Leopoldshafen, Federal Republic of Germany, at the price shown in deutschmarks (DM).

Avail: HMSO. Publications of Her Majesty's Stationery Office are sold in the U.S. by Pendragon House, Inc. (PHI), Redwood City, CA. The U.S. price (including a service and mailing charge) is given, or a conversion table may be obtained from PHI.

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration, Public Documents Room (Room 126), 600 Independence Ave., S.W., Washington, DC 20546, or public document rooms located at each of the NASA research centers, the NASA Space Technology Laboratories, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: Univ. Microfilms. Documents so indicated are dissertations selected from *Dissertation Abstracts* and are sold by University Microfilms as xerographic copy (HC) and microfilm. All requests should cite the author and the Order Number as they appear in the citation.

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of $1.50 each, postage free.

Avail: (US Sales Only). These foreign documents are available to users within the United States from the National Technical Information Service (NTIS). They are available to users outside the United States through the International Nuclear Information Service (INIS) representative in their country, or by applying directly to the issuing organization.

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed in this Introduction. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

FEDERAL DEPOSITORY LIBRARY PROGRAM

In order to provide the general public with greater access to U.S. Government publications, Congress established the Federal Depository Library Program under the Government Printing Office (GPO), with 51 regional depositories responsible for permanent retention of material, inter-library loan, and reference services. At least one copy of nearly every NASA and NASA-sponsored publication, either in printed or microfiche format, is received and retained by the 51 regional depositories. A list of the regional GPO libraries, arranged alphabetically by state, appears on the inside back cover. These libraries are *not* sales outlets. A local library can contact a Regional Depository to help locate specific reports, or direct contact may be made by an individual.

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA – Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

STANDING ORDER SUBSCRIPTIONS

NASA SP-7037 supplements and annual index are available from the National Technical Information Service (NTIS) on standing order subscription as PB91-914100, at price code A04. Current values for the price codes are listed on page APP-5. Standing order subscriptions do not terminate at the end of a year, as do regular subscriptions, but continue indefinitely unless specifically terminated by the subscriber.

ADDRESSES OF ORGANIZATIONS

American Institute of Aeronautics and Astronautics
Technical Information Service
555 West 57th Street, 12th Floor
New York, New York 10019

British Library Lending Division,
Boston Spa, Wetherby, Yorkshire,
England

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Washington, DC 20231

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

European Space Agency-Information Retrieval Service
ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

Engineering Sciences Data Unit International
P.O. Box 1633
Manassas, Virginia 22110

Engineering Sciences Data Unit International, Ltd.
251-259 Regent Street
London, W1R 7AD, England

Fachinformationszentrum Energie, Physik, Mathematik
GMBH
7514 Eggenstein Leopoldshafen
Federal Republic of Germany

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

NASA Center for AeroSpace Information
P.O. Box 8757
BWI Airport, Maryland 21240

National Aeronautics and Space Administration
Scientific and Technical Information Program (NTT)
Washington, DC 20546

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, California 94063

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, Michigan 48106

University Microfilms, Ltd.
Tylers Green
London, England

U.S. Geological Survey Library National Center
MS 950
12201 Sunrise Valley Drive
Reston, Virginia 22092

U.S. Geological Survey Library
2255 North Gemini Drive
Flagstaff, Arizona 86001

U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

U.S. Geological Survey Library
Box 25046
Denver Federal Center, MS914
Denver, Colorado 80225

NTIS PRICE SCHEDULES

(Effective January 1, 1991)

Schedule A
STANDARD PRICE DOCUMENTS AND MICROFICHE**

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 8.00	$ 16.00
A02	11.00	22.00
A03	15.00	30.00
A04-A05	17.00	34.00
A06-A09	23.00	46.00
A10-A13	31.00	62.00
A14-A17	39.00	78.00
A18-A21	45.00	90.00
A22-A25	53.00	106.00
A99	*	*
N01	60.00	120.00
N02	59.00	118.00
N03	20.00	40.00

Schedule E
EXCEPTION PRICE DOCUMENTS AND MICROFICHE**

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
E01	$10.00	$ 20.00
E02	12.00	24.00
E03	14.00	28.00
E04	16.50	33.00
E05	18.50	37.00
E06	21.50	43.00
E07	24.00	48.00
E08	27.00	54.00
E09	29.50	59.00
E10	32.50	65.00
E11	35.00	70.00
E12	38.50	77.00
E13	41.00	82.00
E14	45.00	90.00
E15	48.50	97.00
E16	53.00	106.00
E17	57.50	115.00
E18	62.00	124.00
E19	69.00	138.00
E20	80.00	160.00
E99	*	*

* Contact NTIS for price quote.

** Effective January 1, 1991, the microfiche copy of any new document entering the NTIS collection will be priced the same as the paper copy of the document.

IMPORTANT NOTICE

NTIS Shipping and Handling Charges

U.S., Canada, Mexico — ADD $3.00 per TOTAL ORDER

All Other Countries — ADD $4.00 per TOTAL ORDER

Exceptions — Does NOT apply to:

ORDERS REQUESTING NTIS RUSH HANDLING
ORDERS FOR SUBSCRIPTION OR STANDING ORDER PRODUCTS *ONLY*

NOTE: Each additional delivery address on an order requires a separate shipping and handling charge.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7037(264)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 264)	April 1991
	6. Performing Organization Code NTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program	11. Contract or Grant No.
	13. Type of Report and Period Covered Special Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This bibliography lists 558 reports, articles and other documents introduced into the NASA scientific and technical information system in March 1991.

17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Aeronautical Engineering Aeronautics Bibliographies	Unclassified - Unlimited Subject Category - 01

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price *
Unclassified	Unclassified	164	A08/HC

*For sale by the National Technical Information Service, Springfield, Virginia 22161

☆U.S. GOVERNMENT PRINTING OFFICE: 1991 -527-064/26023

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA

AUBURN UNIV. AT MONTGOMERY LIBRARY
Documents Department
Montgomery, AL 36193
(205) 279-9110 ext.253

UNIV. OF ALABAMA LIBRARY
Reference Department/Documents
Box S
Tuscaloosa, AL 35486
(205) 348-6046

ARIZONA

DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS
Third Floor State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 255-4121

ARKANSAS

ARKANSAS STATE LIBRARY
Documents Service Section
One Capitol Mall
Little Rock, AR 72201
(501) 371-2090

CALIFORNIA

CALIFORNIA STATE LIBRARY
Govt. Publications Section
914 Capitol Mall
Sacramento, CA 95814
(916) 322-4572

COLORADO

UNIV. OF COLORADO
Norlin Library
Government Publications Division
Campus Box 184
Boulder, CO 80309
(303) 492-8834

DENVER PUBLIC LIBRARY
Govt. Pub. Department
1357 Broadway
Denver, CO 80203
(303) 571-2346

CONNECTICUT

CONNECTICUT STATE LIBRARY
231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971

FLORIDA

UNIV. OF FLORIDA LIBRARIES
Documents Department
Library West
Gainesville, FL 32611
(904) 392-0367

GEORGIA

UNIV. OF GEORGIA LIBRARIES
Government Documents Dept.
Athens, GA 30602
(404) 542-8949

HAWAII

UNIV. OF HAWAII
Hamilton Library
Government Documents Collection
2550 The Mall
Honolulu, HI 96822
(808) 948-8230

IDAHO

UNIV. OF IDAHO LIBRARY
Documents Section
Moscow, ID 83843
(208) 885-6344

ILLINOIS

ILLINOIS STATE LIBRARY
Federal Documents
Centennial Building
Springfield, IL 62756
(217) 782-5012

INDIANA

INDIANA STATE LIBRARY
Serials Section
140 North Senate Avenue
Indianapolis, IN 46204
(317) 232-3686

IOWA

UNIV. OF IOWA LIBRARIES
Government Publications Dept.
Iowa City, IA 52242
(319) 335-5926

KANSAS

UNIVERSITY OF KANSAS
Spencer Research Library
Government Documents
Lawrence, KS 66045
(913) 864-4662

KENTUCKY

UNIV. OF KENTUCKY LIBRARIES
Government Publications/Maps Dept.
Lexington, KY 40506
(606) 257-8400

LOUISIANA

LOUISIANA STATE UNIVERSITY
Middleton Library
Government Documents Dept.
Baton Rouge, LA 70803
(504) 388-2570

LOUISIANA TECHNICAL UNIV.
Prescott Memorial Library
Government Documents Dept.
Ruston, LA 71272
(318) 257-4962

MAINE

UNIVERSITY OF MAINE
Raymond H. Fogler Library
Govt. Documents & Microforms Dept.
Orono, ME 04469
(207) 581-1680

MARYLAND

UNIVERSITY OF MARYLAND
McKeldin Library
Documents/Maps Room
College Park, MD 20742
(301) 454-3034

MASSACHUSETTS

BOSTON PUBLIC LIBRARY
Government Documents Dept.
666 Boylston Street
Boston, MA 02117
(617) 536-5400 ext.226

MICHIGAN

DETROIT PUBLIC LIBRARY
5201 Woodward Avenue
Detroit, MI 48202
(313) 833-1409

LIBRARY OF MICHIGAN
Government Documents
P.O. Box 30007
735 E. Michigan Avenue
Lansing, MI 48909
(517) 373-1593

MINNESOTA

UNIVERSITY OF MINNESOTA
Wilson Library
Government Publications
309 Nineteenth Avenue South
Minneapolis, MN 55455
(612) 373-7813

MISSISSIPPI

UNIV. OF MISSISSIPPI LIB.
Government Documents Dept.
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857

MISSOURI

University of Missouri at Columbia Library
Government Documents
Columbia, MO 65201
(314) 882-6733

MONTANA

UNIV. OF MONTANA
Mansfield Library
Documents Division
Missoula, MT 59812
(406) 243-6700

NEBRASKA

UNIVERSITY OF NEBRASKA - LINCOLN
Love Memorial Library
Documents Department
Lincoln, NE 68588
(402) 472-2562

NEVADA

UNIV. OF NEVADA-RENO LIB.
Govt. Pub. Department
Reno, NV 89557
(702) 784-6579

NEW JERSEY

NEWARK PUBLIC LIBRARY
U.S. Documents Division
5 Washington Street
P.O. Box 630
Newark, NJ 07101
(201) 733-7812

NEW MEXICO

UNIVERSITY OF NEW MEXICO
General Library
Government Publications/Maps Dept.
Albuquerque, NM 87131
(505) 277-5441

NEW MEXICO STATE LIBRARY
325 Don Gaspar Avenue
Santa Fe, NM 87501
(505) 827-3826

NEW YORK

NEW YORK STATE LIBRARY
Documents Sect. Cultural Educ. Ctr.
Empire State Plaza
Albany, NY 12230
(518) 474-5563

NORTH CAROLINA

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Davis Library 080A
BA/SS Department Documents
Chapel Hill, NC 27514
(919) 962-1151

NORTH DAKOTA

NORTH DAKOTA STATE UNIVERSITY LIBRARY
Government Documents Dept.
Fargo, ND 58105
(701) 237-8352
In cooperation with Univ. of North Dakota, Chester Fritz Library
Grand Forks

OHIO

STATE LIBRARY OF OHIO
Documents Section
65 South Front Street
Columbus, OH 43266
(614) 644-7051

OKLAHOMA

OKLAHOMA DEPT. OF LIBRARIES
Government Documents
200 NE 18th Street
Oklahoma City, OK 73105
(405) 521-2502, ext. 252

OKLAHOMA STATE UNIV. LIB.
Documents Department
Stillwater, OK 74078
(405) 624-0489

OREGON

PORTLAND STATE UNIV.
Millar Library
934 SW Harrison - P.O. Box 1151
Portland, OR 97207
(503) 229-3673

PENNSYLVANIA

STATE LIBRARY OF PENN.
Government Publications Section
Box 1601
Walnut St. & Commonwealth Ave.
Harrisburg, PA 17105
(717) 787-3752

SOUTH CAROLINA

CLEMSON UNIV. COOPER LIB.
Documents Department
Clemson, SC 29634
(803) 656-5174
In cooperation with Univ. of South Carolina, Thomas Cooper Library, Columbia

TEXAS

TEXAS STATE LIBRARY
Public Services Department
P.O. Box 12927 - 1201 Brazos
Austin, TX 78711
(512) 463-5455

TEXAS TECH. UNIV. LIBRARY
Documents Department
Lubbock, TX 79409
(806) 742-2268

UTAH

UTAH STATE UNIVERSITY
Merrill Library & Learning Resources Center, UMC-30
Documents Department
Logan, UT 84322
(801) 750-2682

VIRGINIA

UNIVERSITY OF VIRGINIA
Alderman Library
Government Documents
Charlottesville, VA 22903
(804) 924-3133

WASHINGTON

WASHINGTON STATE LIBRARY
Document Section
Olympia, WA 98504
(206) 753-4027

WEST VIRGINIA

WEST VIRGINIA UNIV. LIB.
Government Documents Section
P.O. Box 6069
Morgantown, WV 26506
(304) 293-3640

WISCONSIN

ST. HIST SOC. OF WISCONSIN LIB.
Government Pub. Section
816 State Street
Madison, WI 53706
(608) 262-2781
In cooperation with Univ. of Wisconsin-Madison, Memorial Library

MILWAUKEE PUBLIC LIBRARY
Documents Division
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-3065

WYOMING

WYOMING STATE LIBRARY
Supreme Court & Library Bldg.
Cheyenne, WY 82002
(307) 777-5919

National Aeronautics and
Space Administration
Code NTT

Washington, D.C.
20546-0001

Official Business
Penalty for Private Use, $300

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Postage an Fees Paid
National Aeronautics and
Space Administration
NASA-451

Official Business
Penalty for Private Use $300

U.S. MAIL

**SPECIAL FOURTH CLASS MAIL
BOOK**

L1 001 SP7037-26491051050905694
NASA
SCIEN & TECH INFO FACILITY
ACCESSIONING DEPT
P O BOX 8757 BWI ARPRT
BALTIMORE MD 21240

NASA

POSTMASTER: **If Undeliverable (Section 158 Postal Manual) Do Not Return**